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Original Research Article

A Hospital-Based Study To Assess The Predictive Value Of Preoperative Complete Blood Count Components On The Occurrence Of Surgical Site Infection After Surgery

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ABSTRACT

Aim: The aim of this study was to examine whether a set of routine preoperative blood tests including WBCC, CRP, Creatinine (eGFR), albumin and hemoglobin predict the risk of SSI either alone or in combination.
Methods: The observational cohort study was designed to evaluate the optimal timing of surgical antimicrobial prophylaxis. The preoperative blood test parameters hemoglobin, creatinine, albumin, CRP and white blood cell count were collected in those patients considered to have an indication for preoperative blood testing as per clinical standards. A total of 200 patients were included in the analysis for the RCT and hence assessed for the availability of preoperative levels of the blood parameters of interest.
Results: A complete set of preoperative WBCC, CRP, albumin, creatinine and hemoglobin measurements was present for 48 of 100 patients (48%). The 100 patients with preoperative blood tests available were older, had higher ASA scores, had more secondary diagnoses, were more likely to be women. The 30-day SSI rate was higher in patients with preoperative blood work than in the group without (5.8% vs. 4.5%, p=0.044).
Conclusion: This study demonstrates strong associations between the levels of routine preoperative blood parameters and the risk of SSI. However, none of the blood parameters examined in this study showed striking predictive abilities in terms of surgical site infections and hence, the decision to postpone procedures to optimize patient factors that impact preoperative blood results cannot be generally recommended at a defined cut off.

Keywords: Surgical site infection; Preoperative blood testing; Predictive value; biochemical markers

INTRODUCTION

Surgical site infection (SSI) is a common complication after CD. Postoperative SSI increases morbidity, prolongs hospital stay, and significantly reduces the quality of life of patients. Surgical site infections (SSI) account for up to 38% of all nosocomial infections in inpatients and are considered the most common type of nosocomial infections among surgical patients [1,

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[2]. In spite of numerous measures to prevent SSI, up to 5% of all patients undergoing surgery are reported to experience SSI with a substantial increase in morbidity and mortality [3-5]. Furthermore, SSI are associated with prolonged hospital stay and cost [6-8]. The identification of patients at increased risk of SSI before surgery is of importance to endorse pre-and perioperative SSI prevention measures or delay surgery to minimize risk where indicated.

In the literature, there are hematologic parameters associated with inflammation that are not as widely used as white blood cell count (WBC), C-reactive protein or erythrocyte sedimentation rate but have attracted attention in recent years. These parameters include neutrophil-to-lymphocyte ratio (NLR), platelet-lymphocyte ratio (PLR), mean platelet volume (MPV), and platelet-large cell ratio (P-LCR).

However, there is evidence for the following selected preoperative laboratory tests to potentially predict the risk of postoperative complications including SSI. First, preoperatively elevated c-reactive protein (CRP) levels have been reported to be associated with the risk of postoperative surgical site and remote nosocomial infections [9, 10] as well as with other major postoperative complications in cardiac surgery, including renal dysfunction and death [11, 12]. Second, total white blood cell count (WBCC) has been reported to be associated with postoperative complications in surgical patients. One report showed a linear correlation of increasing preoperative WBCC values, even within the normal limits, with postoperative complications, but did not focus on SSI [13]. Third, malnutrition is a common problem in surgical patients, especially in such subsets as the elderly and chronically ill. It is known to adversely affect outcomes in those patients [14]. Albumin has been found to be the most reliable indicator of the nutritional status [15]. Hypoalbuminemia as a marker for malnutrition has been established as an independent risk factor for SSI [16]. Fourth, end stage renal insufficiency is a known risk factor for surgical site infections [17]. Although chronic kidney failure of earlier stages have been shown to be associated with an increased risk for SSI [18], that association have been shown to be less pronounced. Finally, preoperative anemia has been associated with risk of SSI. However, it was not identified as an independent predictor.

The aim of this study was to examine whether a set of routine preoperative blood tests including WBCC, CRP, Creatinine (eGFR), albumin and hemoglobin predict the risk of SSI either alone or in combination.

Methods

The observational cohort study was designed to evaluate the optimal timing of surgical antimicrobial prophylaxis. The preoperative blood test parameters hemoglobin, creatinine, albumin, CRP and white blood cell count were collected in those patients considered to have an indication for preoperative blood testing as per clinical standards from Oct 2021 to Oct 2022 at SMMH Medical College, Saharanpur, U.P., India. The indication for preoperative blood testing at both sites was based on the general condition of the patient, the complexity of the procedure and individual judgment of the physicians on the ward.

The analysis included all patients for whom the above-mentioned preoperative blood parameters were available from blood taken within 3 days before surgery. Hence, this is a retrospective analysis of a prospectively collected dataset. Approval by the local ethics committees was obtained.

Inclusion criteria

Briefly, all inpatients aged 18 years or older undergoing general, oncologic, vascular and orthopedic trauma procedures with an indication for surgical antimicrobial prophylaxis (cefuroxime, in colorectal surgery combined with metronidazole) according to clinical standards were included.

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Exclusion criteria

Contraindication for cefuroxime and/or metronidazole, preexisting antibiotic therapy within 14 days prior to surgery, cognitive impairment, combined operations including other than the above specified surgical subspecialties and emergency procedures with planned incision within 2 hours after indicating the procedure.
All patients in this study provided written consent to participate.

Data

The blood parameters were categorized into groups according to commonly used cut offs. Normal ranges were 35-52g/L for albumin, <10mg/L for CRP (SI conversion factor 9.524), 140 180g/L for hemoglobin in men, 120-160g/L for hemoglobin in women and 3.5x109/L-10.0x109/L for leukocytes. For eGFR values, the CKD-EPI equation was used and ³90mL/min/1.73m2 was considered normal renal function, 60-89mL/min/1.73m2 mildly decreased, 30-59mL/min/1.73m2 moderately decreased, 15-29mL/min/1.73m2 severely decreased and <15mL/min/1.73m2 renal failure. For parameters with three categories, the "low" or the "high" category was combined with the "normal" category when they were not different in terms of outcome. This was the case for albumin, leukocytes and hemoglobin.

Endpoints

The primary endpoint was the occurrence of SSI within 30 days after surgery. In hospital SSI were diagnosed by the surgical team according to clinical standards. In addition, to increase sensitivity, inpatients were regularly seen by members of the RCT study team. Post discharge follow up was performed by trained members of the RCT study team by contacting the patients over the phone. When a post discharge SSI was suspected, hospital charts were reviewed and primary care physicians were contacted for additional information. All suspected SSI were validated by a board-certified infectious diseases specialist.

Statistical analysis

Descriptive statistics are provided for demographic and baseline characteristics and values. Categorical variables are summarized as frequency and percentage. Continuous variables are summarized as mean and standard deviation (SD) and median and interquartile range (IQR) for blood values due to highly skewed distributions. In case of comparisons between groups, Fisher's exact test was used for categorical variables, and t-tests or Kruskal-Wallis tests for continuous variables, as appropriate.

Results

Table 1: Baseline characteristics by availability of blood work

Characteristic	Blood tests available N=100	No blood tests available N=100	p
Gender			
Male	48 (48%)	120 (60%)	<0.001
Female	52 (52%)	40 (40%)	
Age-years (mean (SD))	60.1 (18.7)	54.4 (18.2)	<0.001
ASA score			
1	12 (12%)	24 (24%)	<0.001
2	50 (50%)	52 (52%)	
3	24 (34%)	22 (22%)	
4	4 (4%)	2 (2%)	
Number of secondary diagnoses (mean (SD))	3.5 (2.6)	2.7 (2.3)	<0.001
Wound class			
I	80 (80%)	75 (75%)	<0.001
II	10 (10%)	20 (20%)	
III	6 (6%)	3 (3%)	
IV	4 (4%)	2 (2%)	
BMI** (kg/m2) (mean(SD))	26.5 (6.0)	27.6 (7.6)	<0.001
Duration of surgery (mean (SD))	108.1 (71.7)	108.2 (78.0)	0.950
30 day SSI			
General/oncologic surgery	8 (8%)	5 (5%)	0.044
Orthopedic trauma surgery	2 (2%)	2 (2%)	
Vascular surgery	6 (6%)	4 (4%)	

A total of 200 patients were included in the analysis for the RCT and hence assessed for the availability of preoperative levels of the blood parameters of interest. A complete set of preoperative WBCC, CRP, albumin, creatinine and hemoglobin measurements was present for 48 of 100 patients (48%). Demographics of all patients of the RCT, both with or without preoperative blood tests available, are presented in table 1. The 100 patients with preoperative blood tests available were older, had higher ASA scores, had more secondary diagnoses, were more likely to be women. Further characteristics are shown in table 1.

Table 2: Levels of preoperative blood tests stratified by 30-day SSI status

Variable	Level of blood predictors		p
	Median (IQR)	Mean (SD)	
CRP			
No SSI SSI	3.6 (1.0 – 10.4) 5.7 (1.5 – 15.8)	14.3 (31.1) 22.2 (49.2)	0.002
Leukocytes			
No SSI SSI	8.4 (6.6 – 11.0) 8.0 (6.5 – 9.9)	9.2 (3.6) 8.7 (3.3)	0.24
Albumin			

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No SSI SSI	38.0 (35.0 – 40.0) 35.9 (33.0 – 38.5)	37.1 (4.8) 35.2 (5.4)	<0.0001
eGFR			
No SSI SSI	88.0 (70.6 – 101.8) 81.2 (63.4 – 92.5)	84.7 (25.7) 77.5 (24.4)	0.0012
Hemoglobin			
No SSI SSI	137.0 (127.0 – 148.0) 130.0 (117.0 – 145.0)	135.9 (18.6) 130.7 (20.1)	0.0016

The 30 day SSI rate was higher in patients with preoperative blood work than in the group without (5.8% vs. 4.5%, p=0.044). Preoperative levels of the blood parameters by 30-day SSI status are shown in table 2.

Table 3: Interaction terms and subgroup analyses between surgical department and categorical blood parameters

Predictor	Department	OR	95%CI	p
High CRP	General/oncologic	1.17	[0.72,1.88]	0.123
	Orthopedic trauma	1.23	[0.43,3.03]	
	Vascular	3.61	[1.35,9.18]	
High leukocytes	General/oncologic	0.57	[0.32,0.96]	0.316
	Orthopedic trauma	0.86	[0.33,2.07]	
	Vascular	1.41	[0.45,3.80]	
Low albumin	General/oncologic	2.71	[1.66,4.37]	0.304
	Orthopedic trauma	1.50	[0.59,3.55]	
	Vascular	1.38	[0.51,3.49]	
eGFR				
Mildly decreased	General/oncologic	2.27	[1.35, 3.88]	0.012
Moderately decreased		3.29	[1.67, 6.35]	
Severely decreased/failure		2.19	[0.23, 9.69]	
Mildly decreased	Orthopedic trauma	3.23	[1.16, 10.81]	
Moderately decreased		2.84	[0.63, 11.86]	
Severely decreased/failure		17.13	[3.58, 76.51]	
Mildly decreased	Vascular	0.65	[0.24, 1.83]	
Moderately decreased		0.71	[0.19, 2.33]	
Severely decreased/failure		0.13	[0.00, 1.12]	
Low hemoglobin	General/oncologic	2.31	[1.44,3.69]	0.120
	Orthopedic trauma	5.31	[2.21,14.08]	
	Vascular	1.47	[0.59,3.69]	

When performing subgroup analyses of the categorical blood parameters per surgical department including interaction tests, there is a significant interaction between surgical department and eGFR only (p=0.012). In practice, in general, oncologic and orthopedic trauma surgery, decreased eGFR increased the odds of having SSI whereas in vascular surgery, it decreased the odds of having SSI (table 3). However, within the vascular surgery subgroup, the 95% confidence intervals for the odds ratios for SSI in each of the eGFR categories are wide and cross 1 significantly.

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Discussion

Preoperative white blood cell count did not a have a significant impact on the odds of SSI. Importantly, despite the highly significant associations between several blood parameters and the risk of SSI, none of the tests showed very good abilities to predict SSI when using the blood test values as continuous variables. Similarly, when looking at categorical values, the performance characteristics in terms of sensitivity and specificity were modest. However, the positive predictive values (PPV) ranging between 6% and 10% and the negative predictive values (NPV) of up to 96% showed better predictive abilities to identify patients at increased risk of experiencing SSI and even more so those at low risk, considering the overall SSI rate of 5.8% and its effect on the PPV and NPV.

Another interesting finding of this study was the significant interaction between preoperative CRP level categories (normal vs. high) and the timing of surgical antimicrobial prophylaxis (SAP, early vs. late) in terms of SSI risk. The main results of the RCT showed no significant impact of timing of SAP on the risk of SSI.[19] Based on the present results, however, it could be argued that late administration of SAP before incision increases the odds of SSI in patients with normal preoperative CRP levels, while in patients with elevated preoperative CRP levels, the odds are decreased. Interpretation of this finding is difficult and speculative.

There was weak evidence of an interaction of renal function as calculated by eGFR and the timing of SAP in terms of SSI risk. Although not statistically significant, patients with normal renal function showed a trend towards lower rates of SSI with late administration of SAP while in those with mildly and moderately decreased renal function, the odds of SSI were numerically higher with late administration.

In contrast to previous studies [20, 21], the association of obesity and SSI was not statistically significant. Obesity has previously been reported to predict SSI via various possible factors, including the relative avascularity of adipose tissue. Another factor may be technical difficulties of handling adipose tissue which can result in more traumas to the anterior abdominal wall, or difficulty in obliterating dead space in the fat-tissue of the abdominal wall. The lack of significant association in this study may be due to the fact the Body Mass Index of patients in this study was measured during labour rather than before pregnancy.

Another important risk factor for SSI is the absence or delay of antibiotic prophylaxis. In this study there was no standard policy of antibiotic prescription. The choice of antibiotic administered depends on the surgeon and indication. The antibiotics given in this study could be divided into two groups; an ampicillin-based regimen and a non-ampicillin-based regimen. The timing of antibiotic administration was not consistent. In contrast to previous studies no significant difference was observed regarding type of antibiotic prophylaxis and SSI [22, 23]. The experience of surgeons performing the CS was also a critical determinant of SSI. Excellent surgical technique such as effective homeostasis while preserving adequate blood supply, preventing hypothermia, gently handling tissues, avoiding inadvertent entries into a hollow viscus, choice of appropriate suture material, eradicating dead space, and appropriately managing the postoperative incision are widely believed to reduce the risk of SSI [24].

However, we acknowledge the limitations of this study. First, although the dataset was prospectively collected within a RCT, the study was observational in nature. Second, the 5 blood parameters were chosen based on existing evidence suggesting a possible association with the risk of SSI. We purposefully refrained from exploring other parameters for feasibility reasons. Third, the blood parameters were registered based on their availability in clinical routine, which parallels the selection of patients in need of routine blood work suggesting a more complex patient and procedure population. Accordingly, the role of blood workup to stratify patients undergoing procedures without SAP according to their risk of SSI could be different. However, the low incidence of SSI in most procedures without SAP suggests that any such role may be limited. Last, although this study includes patients undergoing a wide variety of general, oncologic, trauma and vascular procedures, there are other surgical specialties such as cardiac, thoracic or neurosurgery that are not included in this study and hence, our findings

potentially cannot be applied to such patient populations.

CONCLUSION

This study demonstrates strong associations between the levels of routine preoperative blood parameters and the risk of SSI. However, none of the blood parameters examined in this study showed striking predictive abilities in terms of surgical site infections and hence, the decision to postpone procedures to optimize patient factors that impact preoperative blood results cannot be generally recommended at a defined cut off. However, postponement for optimization should be considered in the individual patient, particularly when a potential SSI would have severe consequences.

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