Incidence And Risk Factors For Surgical Site Infection Following Laparotomy At A South African Quaternary Hospital

Natasha Naidoo[1], Thandinkosi Enos Madiba[1], Yoshan Moodley[2]

[1] Department of Surgery, Nelson R. Mandela School of Medicine, University of KwaZulu-Natal, South Africa
[2] Faculty of Health & Environmental Sciences, Central University of Technology, Bloemfontein, South Africa

Abstract
Background**:** A published report of surgical site infection (SSI) incidence and risk factors following laparotomy in a South African (SA) setting is lacking. This information would have important implications for SSI clinical prediction rules in SA patients undergoing this common surgical procedure. This study sought to determine the incidence and associated risk factors for SSI following laparotomy in a SA setting.
Methods: This was a retrospective chart review study of 439 patients who underwent laparotomy at a SA quaternary hospital over a 5-year period. Demographic information, comorbidities, medication use, and surgery-related variables were collected for each patient. The Centers for Disease Control definition of SSI was used in this study. The incidence of SSI was determined using conventional epidemiological methods. Logistic regression was used to identify risk factors for SSI.
Results: The incidence of SSI was 16.6% (CI: 13.4-20.4%). Risk factors for SSI included infectious indication for surgery (Odds Ratio, OR: 3.32, CI: 1.16-9.47; p=0.003), preoperative non-steroidal anti-inflammatory use (OR: 2.82, CI: 1.33-5.95; p=0.007), preoperative hypoalbuminemia (OR: 2.47, CI: 1.12-5.42; p=0.025), Bogota bag use (OR: 2.23, CI: 1.05-4.74; p=0.036), and perioperative blood transfusion (OR: 2.51, CI: 1.33-4.75; p=0.004).
Conclusion: The incidence of SSI in SA patients undergoing laparotomy is higher than that reported for mixed surgical populations. Several risk factors for SSI were identified. The prognostic relevance of these risk factors, and the reduction in SSI risk when these factors are addressed requires further investigation.

***Keywords*:** Surgical site infection, Risk factors, Laparotomy, South Africa

Introduction

Over 234 million people undergo surgery around the world each year [1]. A proportion of these patients will suffer postoperative complications, with surgical site infection (SSI) being amongst the most commonly encountered [2]. Findings from the International Surgical Outcomes Study (ISOS) suggest that the global incidence of SSI is between 0.8% for organ space SSI and 2.9% for superficial SSI [2]. ISOS also reported that mortality in patients with SSI was between 1.3% for patients with superficial SSI and 7.0% for patients with organ space SSI [2]. The African Surgical Outcomes Study (ASOS) reported a higher incidence of SSI in African settings, ranging from 1.1% for organ space SSI to 7.2% for superficial SSI [3]. Mortality in patients with SSI was also higher in ASOS when compared with ISOS, and ranged between 5.2% for superficial SSI to 22.4% for organ space SSI [3]. Information for healthcare expenditure related to SSIs in African settings is not readily available. However, it is likely that there is an association between SSIs and increased healthcare expenditure in African settings, as is the case in other countries around the world [4, 5].

The morbidity, mortality, and potentially increased healthcare expenditure associated with SSIs in African settings highlights the importance of identifying individual patients who might be at risk for this complication in these settings. These patients can then be targeted for additional preventative interventions for SSI which are over and above those interventions that are instituted as standard of care, in order to mitigate some of this risk. Targeting individual high-risk patients for additional SSI prevention interventions rather than all surgical patients would also ensure that this process would not be too resource intensive. This point is relevant in African settings, where public healthcare systems are often under-resourced. Clinical prediction rules are one possible method which can be used to identify high-risk patients for SSI [6, 7]. This method involves the identification of high-risk patients based on the number of risk factors for a specific complication. Every risk factor carries a point score, and a total point score is computed for each patient [8]. A total point score threshold is determined which is then used to classify patients as high-risk or low-risk for the complication [8]. Studies for other postoperative outcomes suggest that some clinical prediction rules might not perform equally well in African surgical settings and in overseas surgical settings where these methods were originally developed [9]. This can be attributed to the difference in the general health profiles between surgical populations in these different settings, which might then impact the relative importance of a risk factor between these different settings [9]. Risk factors for SSI following common major surgical procedures, such as laparotomy, in a South African (SA) setting have not yet been identified. This information would have great importance with regard to the development of a setting-specific clinical prediction rule for SSI. Therefore, the objective of this study was to determine the incidence and associated risk factors for SSI following laparotomy at a SA quaternary hospital.

Patients and methods

Study design and setting:

This retrospective chart review study was conducted at a quaternary hospital located in Durban, SA. The 850-bed quaternary hospital is a public-sector facility and provides various healthcare services to the residents of KwaZulu-Natal province, which is on the east coast of SA. Admission to the hospital is strictly by referral from lower level healthcare facilities. The population served by the hospital is predominantly of black African ethnicity.

Study sample:

The study sample consisted of 439 adult patients undergoing laparotomy. These patients were retrospectively identified from the hospital theater lists. All 439 patients had their surgical procedures performed between 1 January 2006 and 31 December 2010.

Data collection:

Demographic information, comorbidities, medication use, and surgery-related variables were collected for each patient. Demographic information was collected from the patients' admission note. A comorbidity was considered present if there was a physicians' diagnosis attesting to this in the patients' admission notes or progress notes. The indication for surgery was classified as bleed, cancer, infection, trauma, or other. Indication for surgery was established from the operative notes. Medication use was ascertained from the patients' admission notes or from the list of medications administered to the patient while he or she was admitted to hospital. Information for surgery-related variables were obtained from the operative notes and anesthetic record of each patient. The study outcome was SSI following laparotomy. The Centers for Disease Control (CDC) definition of SSI requires the evidence of clinical signs and symptoms of infection and is not solely based on microbiological evidence of infection [10]. Clinical signs and symptoms of infection can include the following: swelling and redness, pain at the site of surgical incision, presence of pus, fever, surgical wound dehiscence, or histopathological or radiological evidence of infection. The CDC further categorizes SSI according to the extent of the infection (Superficial incisional, deep incisional, and organ space infection) [10]. The CDC definition of SSI was used in this study, however there was no additional categorization according to the extent of the infection as all SSIs in this study were deemed to be of importance, irrespective of the extent of the infection. The SSI outcome was measured up to 30 days postoperatively.

Statistical analysis:

Descriptive statistical methods were used to determine the distribution of various characteristics in the study sample. Results for the descriptive statistical analysis are presented as frequencies and percentages. The incidence of SSI in the study sample was calculated using conventional epidemiological equations. Results for this aspect of the statistical analysis are presented as a percentage along with a 95% confidence interval (CI). Potential statistical associations between the various characteristics and SSI were initially tested using bivariate statistical analysis (χ^2 test or Fishers Exact test). Results for the bivariate statistical analysis are presented as frequencies and percentages, along with a corresponding p-value. Characteristics with p<0.100 from the bivariate statistical analysis were then selected for inclusion as independent variables in a logistic regression analysis, with SSI being the dependent variable. This "purposeful" selection of characteristics for inclusion in the logistic regression analysis was performed to ensure that the subsequent regression model was parsimonious [11]. The fit of the regression model was evaluated using the Hosmer-Lemeshow test, with p>0.050 indicative of appropriate model fit. Results for the regression analysis are presented as odds ratios (OR) with CI, and a corresponding p-value. Characteristics with an OR >1.00 and p<0.050 were classified as risk factors for SSI. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp, USA).

Ethical approval:

This study was approved by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal, and the KwaZulu-Natal Provincial Department of Health (Protocol number: BCA208/18).

Results

The characteristics of the study sample, as well as the results of the bivariate statistical analysis are presented in Table 1. Out of the 439 patients undergoing laparotomy in the study sample, 73 patients were identified as having SSI following their procedure. This equated to an estimated SSI incidence of 16.6% (CI: 13.4-20.4%) in the study sample. Variables with p<0.050 which were subsequently included in the logistic regression analysis included: indication for surgery, American Society of Anesthesiologists Score, preoperative non-steroidal anti-inflammatory use, metastatic cancer, preoperative renal impairment, preoperative anemia, preoperative hyponatremia, preoperative hypoalbuminemia, emergency procedure, contaminated procedure, Bogota bag use, antibiotic prophylaxis, and preoperative blood transfusion.

The results of the logistic regression analysis are shown in Table 2. The Hosmer-Lemeshow test indicated appropriate model fit (p=0.381). Statistically significant results were noted for infectious indication for surgery (OR: 3.32, CI: 1.16-9.47; p=0.025), preoperative non-steroidal anti-inflammatory use (OR: 2.82, CI: 1.33-5.95; p=0.007), preoperative hypoalbuminemia (OR: 2.47, CI: 1.12-5.42; p=0.025), Bogota bag use (OR: 2.23, CI: 1.05-4.74; p=0.036), and perioperative blood transfusion (OR: 2.51, CI: 1.33-4.75; p=0.004).

Table 1. Characteristics of the study sample and results of bivariate statistical analysis

Characteristic	Category	All (N=439), n (% N)	SSI (N=73), n (% N)	No SSI (N=366), n (% N)	p
Age>60	>60 years	82 (18.7)	11 (15.1)	71 (19.4)	0.386
	≤60 years	357 (81.3)	62 (84.9)	295 (80.6)	
Gender	Male	145 (33.0)	26 (35.6)	119 (32.5)	0.607
	Female	294 (67.0)	47 (64.4)	247 (67.5)	
Obesity	Yes	152 (34.6)	31 (42.5)	121 (33.1)	0.302
	No	105 (23.9)	15 (20.5)	90 (24.6)	
	Missing	182 (41.5)	27 (37.0)	155 (42.3)	
Indication for surgery	Bleed	12 (2.7)	2 (2.8)	10 (2.7)	<0.001
	Cancer	183 (41.7)	19 (26.0)	164 (44.8)	
	Infection	36 (8.2)	19 (26.0)	17 (4.6)	
	Other	151 (34.4)	19 (26.0)	132 (36.1)	
	Trauma	57 (13.0)	14 (19.2)	43 (11.8)	
American Society of Anesthesiologists Score	>2	207 (47.2)	44 (60.3)	163 (44.5)	0.014
	≤2	232 (52.8)	29 (39.7)	203 (55.5)	
Preoperative non-steroidal anti-inflammatory	Yes	62 (14.1)	17 (23.3)	45 (12.3)	0.014
	No	377 (85.9)	56 (76.7)	321 (87.7)	
Preoperative statin	Yes	25 (5.7)	6 (8.2)	19 (5.2)	0.280
	No	414 (94.3)	67 (91.8)	347 (94.8)	
Hypertension	Yes	140 (31.9)	26 (35.6)	114 (31.1)	0.454
	No	299 (68.1)	47 (64.4)	252 (68.9)	
Diabetes	Yes	57 (13.0)	13 (17.8)	44 (12.0)	0.179
	No	382 (87.0)	60 (82.2)	322 (88.0)	
Cardiovascular disease	Yes	50 (11.4)	5 (6.8)	45 (12.3)	0.181
	No	389 (88.6)	68 (93.2)	321 (87.7)	
HIV	Yes	30 (6.8)	2 (2.7)	28 (7.7)	0.200
	No	409 (93.2)	71 (97.3)	338 (92.3)	
Metastatic cancer	Yes	86 (19.6)	9 (12.3)	77 (21.0)	0.087
	No	353 (80.4)	64 (87.7)	289 (79.0)	
Obstructive airway disease	Yes	25 (5.7)	6 (8.2)	19 (5.2)	0.280
	No	414 (94.3)	67 (91.8)	347 (94.8)	
Gastric ulcers	Yes	17 (3.9)	4 (5.5)	13 (3.6)	0.502
	No	422 (96.1)	69 (94.5)	353 (96.4)	
Current smoker	Yes	44 (10.0)	7 (9.6)	37 (10.1)	0.892
	No	395 (90.0)	66 (90.4)	329 (89.9)	
Preoperative leukopenia	Yes	35 (8.0)	6 (8.2)	29 (7.9)	0.932
	No	404 (92.0)	67 (91.8)	337 (92.1)	
Preoperative thrombocytosis	Yes	47 (10.7)	7 (9.6)	40 (10.9)	0.735
	No	392 (89.3)	66 (90.4)	326 (89.1)	
Preoperative renal impairment	Yes	67 (15.3)	18 (24.7)	49 (13.4)	0.014
	No	372 (84.7)	55 (75.3)	317 (86.6)	
Preoperative anemia	Yes	314 (71.5)	62 (84.9)	252 (68.9)	0.005
	No	125 (28.5)	11 (15.1)	114 (31.1)	
Preoperative hyponatremia	Yes	54 (12.3)	14 (19.2)	40 (10.9)	0.050
	No	385 (87.7)	59 (80.8)	326 (89.1)	
Preoperative hypoalbuminemia	Yes	159 (36.2)	48 (65.8)	111 (30.3)	<0.001
	No	280 (63.8)	25 (34.2)	255 (69.7)	
Emergency procedure	Yes	150 (34.2)	36 (49.3)	114 (31.1)	0.003
	No	289 (65.8)	37 (50.7)	252 (68.9)	
Contaminated procedure	Yes	88 (20.0)	31 (42.5)	57 (15.6)	<0.001
	No	351 (80.0)	42 (57.5)	309 (84.4)	
Surgery duration >2 hours	Yes	153 (34.9)	20 (27.4)	133 (36.3)	0.143
	No	286 (65.1)	53 (72.6)	233 (63.7)	
Bogota bag	Yes	70 (15.9)	47 (64.4)	322 (88.0)	<0.001
	No	369 (84.1)	26 (35.6)	44 (12.0)	
Antibiotic prophylaxis	Yes	366 (83.4)	55 (75.3)	311 (85.0)	0.044
	No	73(16.6)	18 (24.7)	55 (15.0)	
Perioperative blood transfusion	Yes	157 (35.8)	46 (63.0)	111 (30.3)	<0.001
	No	282 (64.2)	27 (37.0)	255 (69.7)	

Patient-controlled analgesia postoperatively	Yes	33 (7.5)	3 (4.1)	30 (8.2)	0.227
	No	406 (92.5)	70 (95.9)	336 (91.8)	

Table 2. Results of the logistic regression analysis

Characteristic	Category	OR (CI)	p
Indication for surgery	Bleed	0.44 (0.08-2.57)	0.361
	Cancer	1.03 (0.34-3.10)	0.961
	Infection	3.32 (1.16-9.47)	0.025
	Other	0.78 (0.31-1.94)	0.588
	Trauma/injury	1.00 (Reference group)	-
American Society of Anesthesiologists Score	>2	1.36 (0.75-2.48)	0.313
	≤2	1.00 (Reference group)	-
Preoperative non-steroidal anti-inflammatory	Yes	2.82 (1.33-5.95)	0.007
	No	1.00 (Reference group)	-
Metastatic cancer	Yes	0.46 (0.20-1.10)	0.080
	No	1.00 (Reference group)	-
Preoperative renal impairment	Yes	0.99 (0.45-2.17)	0.970
	No	1.00 (Reference group)	-
Preoperative anemia	Yes	1.25 (0.57-2.75)	0.582
	No	1.00 (Reference group)	-
Preoperative hyponatremia	Yes	1.35 (0.61-3.00)	0.458
	No	1.00 (Reference group)	-
Preoperative hypoalbuminemia	Yes	2.47 (1.12-5.42)	0.025
	No	1.00 (Reference group)	-
Emergency procedure	Yes	0.59 (0.26-1.31)	0.194
	No	1.00 (Reference group)	-
Contaminated procedure	Yes	1.22 (0.58-2.55)	0.599
	No	1.00 (Reference group)	-
Bogota bag	Yes	2.23 (1.05-4.74)	0.036
	No	1.00 (Reference group)	-
Antibiotic prophylaxis	Yes	0.66 (0.32-1.34)	0.247
	No	1.00 (Reference group)	-
Perioperative blood transfusion	Yes	2.51 (1.33-4.75)	0.004
	No	1.00 (Reference group)	-

Discussion

The incidence of SSI in this study was far higher than that reported for ISOS and ASOS [2, 3]. It is possible that this finding is due to one crucial difference between the current study and ISOS/ASOS, which is that the current study was performed solely in a high-risk major surgery group while ISOS and ASOS were performed in surgical populations which were a mix of major and minor surgical procedures [2, 3]. Open intra-abdominal surgery itself is associated with an increased risk of developing SSI [12]. It is likely that the SSI incidence in ISOS and ASOS was "diluted" by the inclusion of lower risk surgical procedures in these two studies.

Several risk factors for SSI were identified in this study, which confirms the established view of SSI as being multifactorial [13]. These risk factors were infectious indication for surgery, preoperative non-steroidal anti-inflammatory use, preoperative hypoalbuminemia, Bogota bag use, and perioperative blood transfusion. These characteristics were associated with an approximately two- to three-fold increase in risk for SSI. The immune response provides protection against infection. Therefore, when there is a perturbation in the immune response an individual might be more susceptible to infection. The finding for infectious indication for surgery being associated with a higher risk of SSI is probably reflective of underlying immune dysfunction in patients with pre-existing infection. Nonsteroidal anti-inflammatory medications are often prescribed for pain control during the perioperative period [14]. These are also often given when patient is discharged from hospital for pain control, and can be administered orally or as a suppository. As the name implies, these medications control pain by reducing inflammation [15]. This might contribute to an impaired immune response in surgical patients, resulting in a predisposition to SSI. The link between hypoalbuminemia and a higher risk of SSI is well established [16, 17]. Hypoalbuminemia is often considered a sign of malnutrition [18]. Besides impairment of the immune response, malnutrition might also cause impaired wound healing [19]. The intact integument acts as a physical barrier against infection and surgical incisions, which represent disruptions in the integumentary system [20], would remain open for far longer in malnourished individuals. During this time period the disrupted integument at the site of the surgical incision might be susceptible to bacterial colonization [20]. Similarly, the use of a Bogota bag would also leave the disrupted integument susceptible to bacterial colonization [21]. Some blood loss is inevitable during open intra-abdominal surgery [22, 23]. Perioperative transfusion might be proposed to address perioperative blood loss. However, transfusion itself has been found to be associated with an increased risk of several postoperative complications, including SSI [24]. In agreement with the pathophysiology of other risk factors identified in this study, it has been postulated that perioperative transfusion might impair the immune response. This appears to be supported by the findings of a recent study involving patients undergoing gastrointestinal surgery, wherein there was an immunosuppressive gene expression profile exhibited by patients who had received a perioperative blood transfusion [25]. The study had specifically found that that this gene expression profile could have a profoundly negative impact on cells of innate immune response [25], which would therefore make patients who received blood transfusions at higher risk for postoperative infectious complications.

We recommended that additional cohort studies be conducted in order to investigate the prognostic performance of these risk factors as components of a SSI clinical prediction rule. This would assist with the preoperative identification of patients who are at high-risk for SSI following their procedures. It might also be worth considering the potential benefits of trying to address some of the SSI risk factors identified in this study. This could mitigate a portion of the risk for SSI in high-risk patients. For instance, pain in surgical patients could be managed using other analgesics. Malnourished patients should be offered adequate nutritional support [26]. Optimizing surgical technique and the use of anti-fibrinolytic agents are strategies which can be used to prevent excess perioperative blood loss [27]. This could reduce the need for a perioperative blood transfusion. Where there is no option for patients other than blood transfusion, then these patients should have their surgical incisions reviewed more often during the postoperative period for SSI. One cannot mitigate the risk of SSI associated with the indication for surgery. Furthermore, one cannot completely mitigate for the risk of SSI associated with the use of a Bogota bag. These risk factors can be used to identify high-risk patients for more stringent postoperative monitoring.

There were limitations to this research. This study was conducted at a single, quaternary level hospital. The patient profile at this hospital is that of very complex cases which cannot be managed at lower level healthcare facilities. Therefore, the findings of this research might not necessarily be generalizable to other hospitals or other surgical populations. Information regarding the use of over-the-counter and herbal medications, which might have an immune boosting effect in surgical patients, was not collected as part of this study as it was difficult to retrospectively establish the use of these medications from the patients' medical chart. There were also some variables which were not consistently recorded on the patients' notes, for example the composition of suture material used to close the surgical incision. These variables could not be reliably investigated in this study and were excluded from the statistical analysis. The study outcome was only measured until 30 days postoperatively, which is in keeping with the CDC definition for SSI. However, there might possibly have been some patients with delayed SSI, in that they presented with SSI at a time point which fell outside the 30 day postoperative period. These patients would have been considered as SSI-negative in the statistical analysis. Prospective research studies are required to address all the aforementioned limitations.

In conclusion, the incidence of SSI observed in the study sample of SA patients undergoing laparotomy was much higher than that reported in larger studies involving mixed surgical populations. This study also identified several risk factors for SSI following laparotomy in a SA setting. The prognostic relevance of these risk factors, and the reduction in SSI risk when these factors are addressed requires further investigation.

References

1. Weiser TG, Regenbogen SE, Thompson KD, et al. An estimation of the global volume of surgery: a modelling strategy based on available data. Lancet. 2008;372(9633):139-44.
2. The International Surgical Outcomes Study Group. Global patient outcomes after elective surgery: prospective cohort study in 27 low-, middle- and high-income countries. Br J Anaesth. 2016;117(5):601-9.
3. Biccard BM, Madiba TE, Kluyts HL, et al. Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study. Lancet. 2018;391(10130):1589-98.
4. Berger A, Edelsberg J, Yu H, Oster G. Clinical and economic consequences of post-operative infections following major elective surgery in U.S. hospitals. Surg Infect (Larchmt). 2014;15(3):322-7.
5. Coello R, Charlett A, Wilson J, et al. Adverse impact of surgical site infections in English hospitals. J Hosp Infect. 2005;60(2):93-103.
6. van Walraven C, Musselman R. The Surgical Site Infection Risk Score (SSIRS): A Model to Predict the Risk of Surgical Site Infections. PLoS One. 2013;8(6):e67167.
7. Culver DH, Horan TC, Gaynes RP, et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. Am J Med. 1991;91(3b):152s-7s.
8. Sullivan LM, Massaro JM, D'Agostino RB, Sr. Presentation of multivariate data for clinical use: The Framingham Study risk score functions. Stat Med. 2004;23(10):1631-60.
9. Moodley Y, Naidoo P, Biccard BM. The South African Vascular Surgical Cardiac Risk Index (SAVS-CRI): a prospective observational study. S Afr Med J. 2013;103(10):746-50.
10. Mangram AJ, Horan TC, Pearson ML, et al. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Am J Infect Control. 1999;27(2):97-132.
11. Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. Source Code Biol Med. 2008;3:17.
12. Haley RW, Culver DH, Morgan WM, et al. Identifying patients at high risk of surgical wound infection. A simple multivariate index of patient susceptibility and wound contamination. Am J Epidemiol. 1985;121(2):206-15.
13. Young PY, Khadaroo RG. Surgical site infections. Surg Clin North Am. 2014;94(6):1245-64.
14. Dahl JB, Kehlet H. Non-steroidal anti-inflammatory drugs: rationale for use in severe postoperative pain. Br J Anaesth. 1991;66(6):703-12.
15. Kelly DJ, Ahmad M, Brull SJ. Preemptive analgesia I: physiological pathways and pharmacological modalities. Can J Anaesth. 2001;48(10):1000-10.
16. Hennessey DB, Burke JP, Ni-Dhonochu T, et al. Preoperative hypoalbuminemia is an independent risk factor for the development of surgical site infection following gastrointestinal surgery: a multi-institutional study. Ann Surg. 2010;252(2):325-9.
17. Truong A, Hanna MH, Moghadamyeghaneh Z, Stamos MJ. Implications of preoperative hypoalbuminemia in colorectal surgery. World J Gastrointest Surg. 2016;8(5):353-62.
18. van Stijn MF, Korkic-Halilovic I, Bakker MS, et al. Preoperative nutrition status and postoperative outcome in elderly general surgery patients: a systematic review. J Parenter Enteral Nutr. 2013;37(1):37-43.

19. Molnar JA, Underdown MJ, Clark WA. Nutrition and Chronic Wounds. Adv Wound Care (New Rochelle). 2014;3(11):663-81.
20. Ki V, Rotstein C. Bacterial skin and soft tissue infections in adults: A review of their epidemiology, pathogenesis, diagnosis, treatment and site of care. Can J Infect Dis Med Microbiol. 2008;19(2):173-84.
21. Turza KC, Campbell CA, Rosenberger LH, et al. Options for closure of the infected abdomen. Surg Infect (Larchmt). 2012;13(6):343-51.
22. Feltracco P, Brezzi M, Barbieri S, et al. Blood loss, predictors of bleeding, transfusion practice and strategies of blood cell salvaging during liver transplantation. World J Hepatol. 2013;5(1):1-15.
23. Cata JP, Gottumukkala V. Blood Loss and Massive Transfusion in Patients Undergoing Major Oncological Surgery: What Do We Know? International Scholarly Research Notices: Anesthesiology. 2012;2012:11.
24. Pang QY, An R, Liu HL. Perioperative transfusion and the prognosis of colorectal cancer surgery: a systematic review and meta-analysis. World J Surg Oncol. 2019;17(1):7.
25. Fragkou PC, Torrance HD, Pearse RM, et al. Perioperative blood transfusion is associated with a gene transcription profile characteristic of immunosuppression: a prospective cohort study. Crit Care. 2014;18(5):541.
26. West MA, Wischmeyer PE, Grocott MPW. Prehabilitation and Nutritional Support to Improve Perioperative Outcomes. Curr Anesthesiol Rep. 2017;7(4):340-9.
27. Ghadimi K, Levy JH, Welsby IJ. Perioperative management of the bleeding patient. Br J Anaesth. 2016;117(suppl 3):iii18-iii30.

Corresponding Author:
Dr. Natasha Naidoo
Department of Surgery, Nelson R. Mandela School of Medicine, University of KwaZulu-Natal, 719 Umbilo Road, Congella 4013, South Africa
Email: drnnaidoo@outlook.com
Telephone: +27 31 260 4575