Positive Postoperative Blood Cultures in Major Abdominal Surgery Patients Attending a Tertiary Hospital in Durban, South Africa

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Abstract

Background: Evidence from high-income countries suggests that bloodstream infection is an essential complication following major surgery. However, studies of bloodstream infections following major surgery in lower-income settings, particularly in Africa, are rare. This study aimed to determine the incidence of postoperative bloodstream infection and to explore any association with mortality in high-risk laparotomy patients in South Africa.

Methods: This study was a retrospective study, reviewing 435 consecutive adults who underwent laparotomy at a South African tertiary hospital over a five-year period. Incident postoperative bloodstream infection, defined as a positive blood culture following surgery, was determined from laboratory reports in the patient's medical chart. Source infections and the causative microorganisms were established from laboratory reports. Inpatient mortality was determined from the patient's hospital discharge summary. Data were summarized using descriptive statistics. Potential associations between bloodstream infection and mortality were tested using the chi-square test.

Results: The incidence of postoperative bloodstream infection was 7.4%. *Klebsiella pneumoniae, Escherichia coli,* and *Staphylococcus aureus* were isolated from 21.9%, 18.7%, and 15.6% of blood cultures. Mortality in patients with bloodstream infection was 46.9% vs. 16.1% in patients without bloodstream infection ($p<0.001$).

Conclusions: Postoperative bloodstream infection is an essential complication following major abdominal surgery with *K. pneumoniae, E. coli,* and *S. aureus* being the most common causative agents. Bloodstream infection is associated with a higher risk of postoperative mortality. Further studies are recommended to confirm the findings and improve patient management.

Keywords: Blood culture, microbiology, mortality, postoperative period, surgery

Introduction

It is estimated that each year more than 300 million patients undergo surgical procedures worldwide.[1] The International Surgical Outcomes Study group (ISOS) has reported that infectious complications are amongst the most frequently encountered complications during the postoperative period and occur in 9.0% of surgical patients.[2] Moreover, surgical site infection, pneumonia, and urinary tract infections are the most common infectious complications observed during the postoperative period.[3] The causative microbiological agents of these infectious complications occasionally enter the bloodstream, where they may cause a secondary infection.[4] Meanwhile, the ISOS estimated that postoperative bloodstream infections occured in only 0.9% of surgical patients worldwide, the associated mortality was the highest amongst all categories of postoperative infectious complication.[2] Although microorganisms might enter the bloodstream through everyday activities, such as during brushing of teeth, these are efficiently disposed of by the immune system in healthy individuals and do not cause infection.[4] However, anaesthesia and surgery can impair the immune response.[5,6] This might

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explain the incidence of bloodstream infection in surgical patients, as well as the disastrous consequences of this specific postoperative complication.

The microbiological culture of blood specimens remains the gold standard for diagnosing bloodstream infections.[7] Blood specimens can be inoculated into a microbiological culture medium and incubated for a few days to grow medically important microorganisms that may be the causative agents of bloodstream infection. Alternatively, liquid microbiological culture media in blood culture bottles can also 'grow' microorganisms.[7] As most bloodstream infections occur secondary to a surgical site infection, pneumonia, or urinary tract infection, the causative microbiological agent of the bloodstream infection is often the same as the primary infection.[3] False positive results for a blood culture can occur when commensal organisms on the skin, which might be introduced during specimen collection, are 'grown' rather than true pathogenic microorganisms.[7] Bacteria are the most common group of microorganisms isolated from positive blood cultures. The most frequently reported bacterial species isolated from positive blood cultures include: *Staphylococcus spp., Streptococcus spp., Acinetobacter, Corynebacterium, Enterobacteriaceae, Pseudomonas aeruginosa, Clostridium spp.,* and *Bacteroides spp*.[8] Although the African Surgical Outcomes Study (ASOS) reported that only 1.3% of surgical patients experienced postoperative bloodstream infection, postoperative mortality in afflicted patients can be as high as 40%.[9] Therefore, in keeping with the findings of ISOS,[2] bloodstream infections appear to be of importance in African surgical settings.

It should be noted that there were several surgical specialties included in ASOS and ISOS, and there was also no sub-analysis that investigated the occurrence of bloodstream infection according to surgical specialty.[2,9] In addition, ASOS and ISOS were conducted across several countries, and the analysis for infectious complications was not presented by country.[2,9] Due to these limitations, it might be inappropriate to extrapolate the results for bloodstream infections from ASOS and ISOS to a specific South African patient population undergoing major abdominal surgery, such as laparotomy patients. There might be differences in case-mix, resource availability, and other relevant variables between different countries. These differences might have implications regarding the management of bloodstream infections in different settings. There is a paucity in the literature regarding studies that have specifically sought to describe positive postoperative blood cultures in South African major abdominal surgery populations. A South African study of positive postoperative blood cultures in this traditionally high-risk surgical population could improve our country-specific understanding of this complication and improve abdominal surgery patients' clinical management in South African settings. This study aimed to determine the incidence of postoperative bloodstream infection and to explore any association with mortality in a high-risk surgical population of South African laparotomy patients.

Methods

This study was a retrospective chart review at the tertiary-level Inkosi Albert Luthuli Central Hospital (IALCH) in Durban, South Africa. The inclusion criteria for the study were laparotomy surgery patients, aged >18 years old, had the laparotomy at IALCH between January 2006 and December 2010. The exclusion criteria were repeat laparotomies for the same patient or if the patient had missing data for the postoperative period. We found the patients for our study by looking through the operating room register throughout the study period. After applying the inclusion and exclusion criteria, the study sample consisted of 435 consecutive adult patients.

All patient data were collected through a retrospective chart review process, maintained as an electronic patient registry. Source documents reviewed during this process included patient admission notes, physicians' or surgeons' progress notes, laboratory reports, and the patient discharge summary. The variables investigated in this study included patient demographic characteristics, indications for surgery, the urgency of surgery, comorbidities, laboratory results, and postoperative mortality. The study outcome was bloodstream infection, as defined by a positive blood culture result following surgery. For this study, a positive blood culture result was defined as any postoperative blood culture which yielded a pathogenic microbial isolate. Culture results reported as contaminants were not considered to be positive blood cultures. Blood cultures were serially performed; therefore, blood specimens from a patient that consistently yielded no microbial growth were considered negative for bloodstream infection. All blood cultures were performed at a SANAS-accredited laboratory within the IALCH complex. Mortality was collected as a separate variable in the patient registry and was determined from the patient discharge summary.

Data were analyzed using quantitative techniques. Descriptive statistics were used to determine the distribution of various characteristics in the study sample. Results for the descriptive statistical analysis were presented as medians with interquartile range (IQR) or as frequencies and percentages. The cumulative incidence of positive blood cultures following laparotomy was calculated using standard epidemiologic methods and presented as a percentage along with a corresponding 95% confidence interval (CI). The microbiology of positive blood cultures following laparotomy was descriptively presented as frequencies and percentages. We compared the proportion of patients who had long operations (>2 hours), contaminated procedures, and blood transfusions between the positive blood culture group and the negative blood culture group with the chi-square test. Bivariate statistics, namely the chi-square test, was used to compare mortality between patients with and without positive blood culture results. The results of the bivariate statistical analysis for mortality were presented as a crude odds ratio with a 95% CI. Statistical significance was set at $p<0.050$. The statistical analysis was performed using the Statistical Package for the Social Sciences, version 27.0 (IBM, USA).

This study was approved by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal, South Africa (Protocol number BREC/00000870/2019).

Results

Of the 435 selected patients, 292 (67.1%) were male with a median age of 42 years old (IQR: 30.0–56.0) (Table 1). The laparotomy was electively performed in 288 patients (66.2%). Cancer (n=183; 42.1%), and trauma or injury (n=149; 34.3%) were the most common indications for surgery. Hypertension (n=140; 32.2%), metastatic carcinoma (n=88; 20.2%), and diabetes (n=57; 13.1%) were the most prevalent comorbidities.

Of the study sample comprising 435 patients, 32 had positive blood culture during the postoperative period (Cumulative incidence: 7.4%, 95% CI: 5.3–10.2%). A comparison of the incidence between positive blood culture and other types of healthcare-associated infections (pneumonia, surgical

Table 1 Characteristics of Patients undergoing Laparotomy at the Tertiary-level Inkosi Albert Luthuli Central Hospital in Durban, South Africa Period 2006 to 2010 (n=435)

Characteristic	n (%)
Demographics	
Male	292 (67.1)
Median age; years (Interquartile range)	42 (30–56)
Indication for surgery	
Bleeding	12 (2.8)
Cancer	183 (42.1)
Infection	35 (8.0)
Trauma/Injury	149 (34.3)
Other	56 (12.9)
Urgency of surgery	
Elective	288 (66.2)
Emergency	147 (33.8)
Comorbidity	
Hypertension	140 (32.2)
Diabetes mellitus	57 (13.1)
Cardiovascular disease	50 (11.5)
Metastatic carcinoma	88 (20.2)
Obstructive lung disease	25 (5.7)
Current smoker	44 (10.1)

Table 2 Comparison of Important Characteristics between Positive and Negative Blood Culture Groups

Characteristic	Positive Blood Culture (n=32)	Negative Blood Culture (n=403)	P-value
Surgery >2 hours, n (%)	18 (56.3)	155 (38.5)	0.048
Contaminated procedure, n (%)	14 (43.8)	72 (17.9)	<0.001
Blood transfusion, n (%)	25 (78.1)	130 (32.3)	<0.001

site infection, urinary infection) showed that positive blood culture was the third most important (7.4%) after surgical site infection (14.9%) and pneumonia (8.5%) (Figure).

The comparison of long surgery (>2 hours), contaminated procedure, and blood transfusion in the positive and negative blood culture groups showed that all three characteristics were significantly higher in patients who had positive blood cultures when compared with patients who had negative blood cultures (Table 2).

The microbiology of positive blood cultures in this study showed that more than one species of microorganism was isolated from three of these blood cultures. The source of the bloodstream infection was established in 17 of 32 positive blood cultures, with the most common source being infection of intra-abdominal origin (n=9). The three most commonly isolated microorganisms from blood cultures in this study were *Klebsiella pneumoniae* (7 of 32), *Escherichia coli* (6 of 32), and *Staphylococcus aureus* (5 of 32) (Table 3).

Postoperative mortality in the entire study sample was 18.4% (80/435 patients). Of the patients without positive blood cultures (n=403), there were 65 postoperative deaths. This group equated to a mortality rate of 16.1% (95% CI: 12.9-20.0%). Of the patients with positive blood cultures (32 patients), there were 15 postoperative deaths. This equated to a mortality rate of 46.9% (95% CI: 30.9-63.6%) in this group. When postoperative mortality was statistically compared between the two

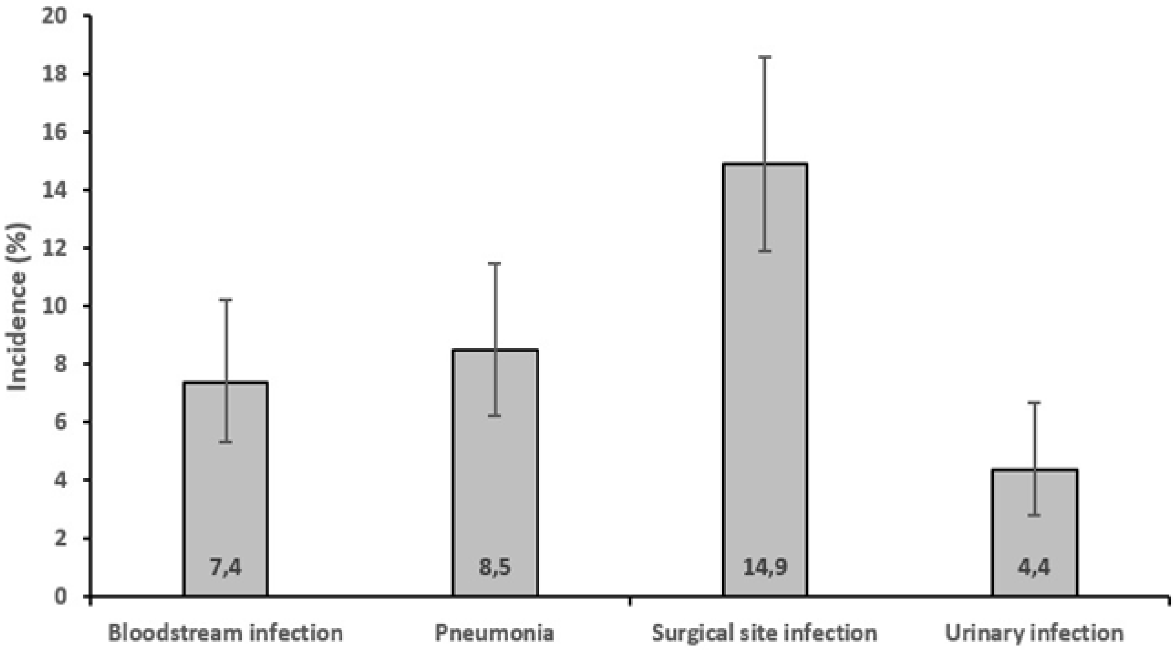

Figure 1 Comparison of Positive Blood Culture Incidence with Other Types of Healthcare-associated Infections

Table 3 Description of the Microbiology of Positive Blood Cultures (n=32)

Characteristic	n
Polymicrobial infection	3
Possible source of infection	
Intra-abdominal infection	9
Pneumonia	3
Urinary tract infection	3
Catheter	2
Could not be established	15
Microorganisms	
Acinetobacter baumanii	3
Candida albicans	4
Enterobacter aerogenes	1
Enterobacter cloacae	3
Enterococcus faecalis	4
Escherichia coli	6*
Klebsiella pneumoniae	7*
Morganella morganii	1
Staphylococcus aureus	5*
Stenotrophomonas maltophilia	1

Note: *the most prevalence microorganism in blood culture of patients undergoing laparotomy

groups, patients with positive blood cultures were found to have a 4.6-fold higher risk of postoperative mortality when compared with patients who did not have positive blood cultures (Odds ratio=4.6, 95% CI: 2.2–9.6; p<0.001).

Discussion

This study reports three key findings. Firstly, approximately 7 in every 100 major abdominal surgery patients suffered a postoperative bloodstream infection in our setting. Secondly, the common causative agents of bloodstream infection in our setting were *K. pneumoniae, E. coli,* and *S. aureus*. Lastly, bloodstream infection was associated with a 4.6-fold higher risk of postoperative mortality.

The incidence of bloodstream infection in this study was 8.2 times higher than that reported for ISOS and 5.7 times higher than that reported for ASOS.[2,9] This variation can be attributed to the difference in case-mix between our study compared to both the ISOS and ASOS studies. ISOS and ASOS included a combination of minor and major surgical procedures, whereas our dataset comprised major surgery patients exclusively. The incidence of bloodstream infection in ISOS and ASOS may be diluted by including low-risk surgeries in these studies. Patients undergoing major surgical procedures are at higher risk for infection due to comorbidity and risk factors for source infections when compared with patients undergoing less invasive surgical procedures. Severe or advanced comorbidity may usually be present in patients undergoing major surgery, which might impair healing and/or the immune response to infection in the perioperative period.[10] This would then predispose these patients to source infections and subsequent bloodstream infection. Major surgery also involves long skin incisions for surgical access and the duration of procedures can exceed two hours.[11,12] These factors can increase the exposure time for the development of source infections.[11,12]

The three most commonly isolated microorganisms from blood cultures in this study (*K. pneumoniae, E. coli,* and *S. aureus*) are well known causative agents of infectious complications during the postoperative period. *Klebsiella pneumoniae* and *E. coli* are often reported as some of the most common microorganisms associated with bloodstream infections.[13] The incidence of *K. pneumoniae* bloodstream infections has been increasing worldwide over many years.[13] *Escherichia coli* can cause deep surgical site infection if the bowel is inadvertently perforated during abdominal surgery or might cause infection due to poor toilet hygiene and poor care of the surgical wound during the postoperative period.[14] *Staphylococcus aureus* is a commensal organism found on the skin surface but has the potential to cause infection of surgical incisions.[14] Our findings for the presumed source of the bloodstream infection further emphasize the importance of pneumonia, surgical site infection, and urinary tract infection on secondary bloodstream infections in a high-risk surgical population.

Our study association between bloodstream infection and mortality agrees with that reported for ISOS and ASOS. Patients with a bloodstream infection are at higher risk for postoperative mortality when compared with patients who do not have a bloodstream infection. However, there was a difference in the magnitude of the incidence of mortality observed in our study compared with that reported for ISOS and ASOS. In our study, the incidence of mortality in patients with bloodstream infection was approximately four times higher than that reported by ISOS and 11 times higher than that reported by ASOS. It highlighted an essential difference in the epidemiology of this complication between populations undergoing procedures of varying surgical complexity (low-risk versus high-risk procedures) and the specific major surgery (high-risk procedure) population.

Based on our study findings, we propose three recommendations. Firstly, we propose that the risk of postoperative bloodstream infection and its consequences are communicated to major surgery patients during the consent process for their procedures. Secondly, we recommend that physicians and surgeons adhere to infection control policies and implement additional strategies to reduce the risk of postoperative source infections in patients undergoing major surgical procedures in our setting. Some of these strategies might include antibiotic prophylaxis within 30 minutes of skin incision, disinfection of hands, adhering to aseptic techniques during invasive anaesthetic procedures (eg., central venous catheter insertion, arterial line insertion, epidural catheter insertion, and others). Also, maintaining normothermia intraoperatively, limiting the number of people present in theatre to only essential personnel, donning face masks, and newer strategies such as glycaemic control, transfusing blood and blood products only if necessary, and conforming to enhanced recovery after surgery (ERAS) principles.[15] Lastly, we recommend implementing more stringent monitoring for the source of infections following major surgery in our setting.

This study has several strengths. An adequate sample size of 435 patients was tested for a statistical association between positive blood cultures and postoperative mortality. Furthermore, the study population was appropriate, consisting of patients undergoing a high-risk surgical procedure associated with infectious complications during the postoperative period. We were also able to provide a thorough description of the microbiology of positive blood cultures. However, there were also several limitations to this study. The data were obtained from a single, tertiary level center and our study findings might not be completely generalizable to other settings. Only inpatient outcomes were considered as there was no post-discharge follow-up of patients. There is a possibility that out-of-hospital bloodstream infection could have been missed. Similarly, mortality was measured at the inpatient level only. Furthermore, this was a retrospective study, so the possibility of errors in record keeping cannot be ruled out.

We acknowledge that this research has limitations, and these limitations can only be addressed through extensive, prospective, multicenter research studies, including post-discharge follow-up.

In conclusion, postoperative bloodstream infection is a critical complication in South African patients undergoing major abdominal surgery. Interpretation of the microbiological culture results suggests that *K. pneumoniae, S. aureus,* and *E. coli* are essential pathogenic microorganisms in those patients with postoperative bloodstream infections. In keeping with reported outcomes from ISOS and ASOS, bloodstream infection is associated with significant postoperative mortality. This study is essential as it provides information on postoperative bloodstream infections, which will help improve the management of patients with this condition in the future. We recommend further studies to confirm our findings, as additional research on this topic is needed to improve patient management.

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