# Factors Predictive of 30-Day Postoperative Mortality in HIV/AIDS Patients in the Era of Highly Active Antiretroviral Therapy

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**Background:** Factors that predict HIV (human immunodeficiency virus)/AIDS patient postoperative mortality have remained poorly defined.

**Objectives:** The primary objective of this study was to identify factors predictive of short-term, postoperative mortality in HIV/AIDS patients. The secondary objective of this study was to develop a scoring system that would predict short-term postoperative mortality in HIV/AIDS patients.

**Methods:** We retrospectively reviewed all HIV/AIDS patients who underwent surgical procedures in British Columbia, Canada, between April 1995 and March 2002. The primary outcome evaluated was 30-day postoperative mortality. Demographic, clinical, and hospitalization-related data were obtained and utilized to predict outcomes using a logistic regression model.

**Results:** A total of 2305 procedures were carried out on 1322 patients during the study period. Admissions were classified as urgent/emergent for 1311 procedures (57%) and the overall 30-day postoperative mortality was 9.5% (126 deaths). Urgent/emergent admission, older age, prior surgery, a CD4 cell count of $\leq 50$ cells/mm$^3$, a hemoglobin level $\leq 120$ g/L, and a white blood cell count $>11$ g/L within 90 days before the surgical procedure was predictive of an increased 30-day postoperative mortality in a multivariate model. Using these variables, we formulated the HIV Surgical Mortality Score (HSMS) to obtain the median-estimated probability of postoperative death.

**Conclusions:** For accurate preoperative mortality risk stratification for HIV/AIDS patients, we have found that several clinical and laboratory variables must be evaluated. If appropriately validated, our proposed HSMS could be utilized to estimate the probability of short-term postoperative death among HIV/AIDS patients.

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The prevalence of individuals infected with human immunodeficiency virus (HIV) or diagnosed with AIDS has steadily increased in Canada, and also worldwide.[1–3] At the end of 2008, there were an estimated 65,000 Canadians living with HIV/AIDS.[1] Worldwide, approximately 33 million people were living with HIV/AIDS at the end of 2009.[3] With the introduction of highly-active antiretroviral therapy (HAART) in 1996, the life-expectancy of HIV-infected people has improved dramatically.[4,5] Thus, most physicians, including surgeons, are likely to be involved in the care of HIV/AIDS patients.[6] Despite operations currently being routinely carried out on individuals diagnosed with HIV/AIDS, the literature evaluating their outcomes is very limited. Studies previously reported from North American and European centers are limited by the low incidence of HIV in their populations and thus their consequential small study cohort sizes. Many of the studies were also carried out before utilization of HAART.[7] For similar reasons, studies of surgical outcomes in populations where HIV/AIDS is endemic, but for which HAART is not consistently utilized, and medical and surgical resources are less comparable to those available in resource-rich settings, are also difficult to extrapolate to our current patient population.[7]

Review of the literature has identified a highly variable postoperative mortality risk for HIV/AIDS-infected patients, with reports ranging from very poor outcomes in older studies[8–12] to outcomes similar to those reported in individuals not infected with HIV.[6,13–15] Thus, a study identifying factors predictive of postoperative mortality in HIV/AIDS patients receiving HAART is both timely and important. Several clinical and laboratory variables have been previously reported to be predictors of adverse outcomes following surgical procedures carried out on HIV/AIDS patients. The most common of these prognostic variables include: patient age, urgency of surgical admission, the presence of an AIDS diagnosis at the time of surgery, patient utilization of HAART, and laboratory tests that include white blood cell (WBC) count, hemoglobin level, albumin level, CD4 cell count, and plasma viral load.[6,9,13,16–18]

Since 1992, the British Columbia Centre for Excellence in HIV/AIDS (BC-CFE) has followed all HIV/AIDS patients who have received antiretroviral therapy in British Columbia (BC), Canada. The primary objective of this study was to utilize the BC-CFE HIV/AIDS population-based registry of HIV-positive patients ever on HIV treatment to retrospectively identify factors predictive of postoperative mortality in HIV/AIDS patients undergoing surgical procedures. The secondary objective of this study was to develop a scoring system that would predict HIV/AIDS patients' risk of dying from an operation.

## METHODS

The BC-CFE HIV/AIDS, through its Drug Treatment Program (DTP), is mandated by the government of BC to distribute antiretroviral medications free of charge to all clinically eligible individuals in the province who have been diagnosed with HIV/AIDS. The DTP distributes antiretroviral medications in accordance with the BC Therapeutic Guidelines, which are consistent with guidelines from the International AIDS Society of United States since 1996, and its last revision in 2010.[19] The distribution of antiretroviral medications through the DTP has been previously described in detail.[20] Physicians enter individuals into the DTP when they are first prescribed HAART. The enrolling physician must complete a drug request form that acts as a legal prescription and is used to compile baseline information including past HIV-specific drug history, CD4 cell counts, plasma viral load levels, current drug requests, and enrolling-physician data. Prospectively collected data from the DTP includes the drugs composing HAART regimen, the presence

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of a concurrent Hepatitis B and/or C infection, a history of intravenous drug use, and if there was ever a diagnosis of AIDS before surgical admission. Clinical data (medical history and laboratory investigations) and hospitalization events were linked retrospectively. Periodic data linkages were also carried out with the Ministry of Health's Hospital Programs to collect data on type and urgency of surgical procedure/hospital admission, Pharmacare, and Vital Statistics databases. We reviewed the available data for all individuals from the DTP database who underwent a surgical procedure at a BC health care facility between April 1, 1995, and March 31, 2002. Dental and endoscopic procedures were excluded from the analysis. The primary outcome evaluated was 30-day postoperative mortality. Surgical procedures were grouped on the basis of surgical specialty areas, and the top 3 procedures for each specialty area were identified. This study was carried out with the approval of our institutional research ethics board.

By univariate analysis, the following variables were assessed using the Fisher exact test for categorical variables, and the Wilcoxon rank sum test for continuous variables: gender, urgent/emergent hospital admission, proximity of previous surgeries (if any), ever use of HAART before procedure date, procedure type, HAART adherence in the first year of treatment, ever an injection drug user, AIDS diagnosis before surgery, age at the time of surgery, whether or not the surgery was carried out at a teaching hospital, and 4 laboratory test results (CD4 cell count, plasma viral load, hemoglobin level, WBC count) that were measured within 90 days before the surgery date. If a patient had more than 1 laboratory result within 90 days before their surgery date, only the values closest to the date of their procedure were included in this analysis. Only those variables with $P \leq 0.20$ were placed in a multivariate logistic model to evaluate their association with the outcome variable (death within 30 days of the surgical procedure) and the final multivariate model was established by using the AIC (Akaike Information Criterion) selection method. The final multivariate results gave us the best explanatory models. Variables from the multivariate model with $P < 0.05$ were considered significantly associated with 30-day postoperative mortality.

The inferential goodness-of-fit test is the Hosmer-Lemeshow test that yielded an insignificant $P$ value ($P = 0.51$), suggesting that the model fits the data well. The model estimated the probability of 30-day postoperative mortality for each individual. The validation of the predicted probabilities can be assessed by the C statistic. Here we have a C statistic of 0.85 showing very good prediction accuracy.

The logistic regression predicts the logit function of an event outcome from a set of predictors. The logit is the natural log of the odds (probability/1-probability) and is a linear combination of all the predictors. It then can be transformed back to the probability scale. So by doing this, we constructed an HIV Surgical Mortality Score (HSMS), with a higher score indicating a greater chance of death within 30 days after a patient's last surgical procedure. All analyses were conducted using SAS version 9.1.3 (SAS, Cary, NC).

## RESULTS

A total of 4516 surgical procedures were carried out on individuals diagnosed with HIV/AIDS and receiving HAART during the 7-year study period. Of these, 1303 procedures were excluded (207 dental and 1096 endoscopic procedures), and an additional 32 procedures were excluded because patients were younger than 19 years, leaving 3181 procedures carried out on 1823 patients. Further excluding individuals who did not have complete CD4 cell count information available before the last procedure, left a final study cohort of 1322 patients who underwent 2305 operations (average 1.74 operations/patient). At the time of surgery, the median age of the patients under study was 40 years (interquartile range [IQR]: 35–40 years) and 1097 patients (83%) were male gender. The overall 30-day postoperative mortality for the study cohort was 9.5% (126 deaths). Table 1 summarizes the demographic characteristics of the study population. No patients were antiretroviral naïve before their surgical admission, though only 950 patients (72%) had ever started HAART before surgery, and 411 patients (31%) had ever had an AIDS diagnosis before their operation. As well 354 study patients (27%) reported a history of injection drug use. The majority of operations (81%) were carried out in a teaching hospital and the majority of hospital admissions were categorized as urgent/emergent (1311 admissions, 57%), with the remaining 994 procedures (43%) being elective. The most common procedures categorized by surgical specialty and the top 3 procedures of each specialty area are summarized in Table 2. General and vascular surgical procedures, along with respiratory and thoracic surgical procedures, accounted for approximately half of all operations carried out on the study cohort. The single most commonly carried out procedure was bronchoscopy with biopsy (16%).

Surgery at a teaching hospital, ever use of HAART before surgery, ever having an AIDS diagnosis, adherence to antiretroviral therapy, and plasma viral load level were found by bivariate analysis to be significantly associated with 30-day postoperative mortality (Table 3). However, subsequent multivariate logistic regression modeling did not identify these variables as significant predictors of surgical mortality.

Complete laboratory data including plasma viral loads, CD4 counts, hemoglobin, and WBC count data within 90 days before the surgical procedure were available for 855 patients and were included in multivariate analysis. This analysis (n = 855) identified independent predictors of postoperative mortality: age (adjusted odds ratio [AOR] 1.83; 95% confidence interval [CI]: 1.37–2.44), urgent/emergent hospital admission (AOR 2.77; 95% CI: 1.24–6.21), a CD4 cell count 50 cells/mm$^3$ or less (AOR 2.69; 95% CI: 1.27–5.71), a hemoglobin level 120 g/L or less (AOR 4.61; 95% CI: 2.24–9.51), a WBC count more than 11 g/L (AOR 5.73; 95% CI: 2.69–12.19), and having undergone a previous surgical procedure within 6 months (AOR 2.01; 95% CI: 1.05–3.85) were significantly predictive of 30-day postoperative mortality (Table 4).

An HSMS formula for each patient was created on the basis of the model in Table 3 and defined as: $lp = -7.60 + 6.00 \times$ (age at surgery) + 0.99 (if CD4 cell count $\leq$ 50 cells/mm$^3$) + 0.59 (if 50 < CD4 cell count $\leq$ 200) cells/mm$^3$ + 1.53 (if hemoglobin level $\leq$ 120 g/L) + 1.74 (if WBC count > 11 g/L) + 1.02 (if urgent/emergent hospital admission) + 0.70 (if prior surgery within 6 months) + (−0.37) (if prior surgery before 6 months)

If the condition for each variable is not met (ie, CD4 cell count > 200, hemoglobin level > 120 g/L, WBC < 11 g/L, elective hospital

**TABLE 1.** Demographic Characteristics of All HIV/AIDS Surgical Patients ($N$ = 1322) and Operations ($N$ = 2305)

| Variable | N | % |
|---|---|---|
| Patients | | |
| Mean age | 41 | — |
| Male gender | 1097 | 83% |
| Ever AIDS diagnosis before surgery | 411 | 31% |
| Ever started HAART before surgery | 950 | 72% |
| IV drug user | 354 | 27% |
| Procedures | | |
| Procedure at teaching hospital | 1878 | 81% |
| Urgent/emergent admission | 1311 | 57% |

**TABLE 2.** Operations by Surgical Specialty and Top 3 Operations From Each Specialty (Total Operations = 2305)

| Specialty | Total Operations, n (%) | Top 3 Operations, n (%) |
|---|---|---|
| General/vascular surgery | 735 (31.89) | |
| Local excision or destruction of other lesion or tissue of anus | | 110 (14.97) |
| Insertion of totally implantable vascular access device | | 49 (6.67) |
| Biopsy of lymphatic structure | | 47 (6.39) |
| Respiratory/thoracic surgery | 464 (20.13) | |
| Biopsy of bronchus by bronchoscopy | | 369 (79.53) |
| Insertion of intercostal catheter for drainage | | 25 (5.39) |
| Biopsy of lung | | 22 (4.74) |
| Neurosurgery | 279 (12.10) | |
| Spinal tap | | 234 (83.87) |
| Biopsy of brain | | 21 (7.53) |
| Excision or destruction of lesion or tissue of brain | | 3 (1.08) |
| Orthopedics | 173 (7.51) | |
| Arthrocentesis | | 23 (13.29) |
| Open reduction of fracture with internal fixation, tibia, and fibula | | 13 (7.51) |
| Open reduction of fracture with internal fixation, radius, and ulna | | 7 (4.05) |
| Obstetrics/gynecology | 129 (5.60) | |
| Cervical cesarean section | | 24 (18.60) |
| Other manually assisted delivery | | 19 (14.73) |
| Vacuum aspiration for termination of pregnancy | | 16 (12.40) |
| Other | 525 (22.78) | |
| Biopsy of bone marrow | | 39 (7.43) |
| Percutaneous abdominal paracentesis | | 34 (6.48) |
| Phacofragmentation and aspiration of cataract | | 32 (6.10) |

admission, and if no prior surgery), the variable in the formula is scored as zero. This score was then transformed to form our HSMS using the formula that explains the chance of death for each patient after their last operation:

$$\left(\frac{e^{lp}}{1+e^{lp}}\right) \times 100$$

Table 5 presents the distribution of our estimated HSMS when the patients are categorized by the factors included in the final multivariate model. As shown here, a higher score predicts a greater chance of 30-day postoperative death. For example, a patient with a CD4 less than or equal to 50 has a median (IQR) calculated HSMS of 13.51 (7.06–23.52). The Figure shows the distribution of HSMS scores for selected associated factors. We also calculated the sensitivity and specificity of the HSMS, and Table 6 presents the sensitivity and specificity of the HSMS at defined cut points. Selecting an HSMS of 10 yields a sensitivity and specificity of 83% and 79%, respectively.

## DISCUSSION

We reviewed 2305 operations carried out in 1322 HIV-positive patients living throughout British Columbia, Canada, between 1995 and 2002 with an overall 30-day postoperative mortality of 9.5%. In a multivariate analysis of the 855 patients for which complete laboratory data was available, urgent/emergent surgical admission, older age, prior surgery, and within the 90 days before the surgical procedure: a CD4 cell count less than 200 cells/mm$^3$, a hemoglobin level 120 g/L or less, and a WBC count more than 11 g/L were predictive of an increased 30-day postoperative mortality. Thirty-day postoperative mortality among these patients was 7.5%. Using these variables, we formulated the HSMS that calculates the median-estimated probability of postoperative death.

This is the first study to develop a test with high sensitivity and specificity that can predict 30-day postoperative surgical mortality in HIV/AIDS patients. Few prior reports have identified risk factors for mortality in HIV/AIDS surgical patients. The improvement in life expectancy of individuals diagnosed with HIV/AIDS, largely as a result of HAART and its effect of making HIV/AIDS a more chronically manageable condition, has led to an increased need for both emergent and elective surgical procedures, and has brought into question the relevance of observations made from studies conducted during the pre-HAART era. In addition, observations made in previous studies are usually limited by their small sample sizes and their focus on only very specific surgical procedures. In the current study, the BC-CFE HIV/AIDS population-based registry allowed us to evaluate surgical mortality for a broad range of surgical procedures (>2300) carried out on HIV/AIDS patients between 1995 and 2002. The vast majority of these operations were carried out on patients who were receiving HAART.

Recent studies describe postoperative mortality as being similar for HIV-infected and non–HIV-infected individuals for several different types of procedures.[6,13–15,21,22] Patel et al[13] recently reported a case-control study, based upon data from the National Trauma Data Bank (NTDM), evaluating the impact of select chronic organ system dysfunction on trauma-related morbidity and mortality. In a cohort of 686 HIV/AIDS patients, case-matched to 1297 HIV noninfected controls, there was no statistically significant difference in mortality (5.98% vs 6.71%; $P = 0.53$).[13] The 30-day postoperative surgical mortality has not been previously reported in a large population-based cohort of individuals infected with HIV/AIDS. A diagnosis of AIDS at the time of surgery has been previously reported to be associated with higher operative morbidity and mortality.[17] In the current study, despite a significant proportion of individuals ever having an AIDS diagnosis at the time of their operation (31%), the postoperative mortality remained low for these patients. In our study population, an AIDS diagnosis before surgery was also not found to predict 30-day postoperative mortality. Although there are contradictions in the current literature regarding the impact of HAART on surgical outcomes,[6,7,12–18] we believe that the adoption of HAART during the study period significantly improved the outlook for HIV/AIDS patients. Thus, the overall improvement in the general health status and life expectancy of HIV/AIDS patients receiving HAART likely makes an important contribution to the relatively low postoperative mortality we observed in our study population. This is important because in the current era of HAART this study shows strong evidence to suggest that surgical intervention on the majority of HIV-infected individuals may be considered safe and appropriate.

**TABLE 3.** Characteristics of Patients Who Died After Last Operations and Those Who Did Not Die After Last Operations (N = 1322)

| | 30-Day Postoperative Outcome | | |
|---|---|---|---|
| **Variable** | **Survived (N = 1196)** | **Died (N = 126)** | ***P*** |
| Urgent/emergent admission | | | |
| No | 560 (46.82) | 14 (11.11) | <0.001 |
| Yes | 636 (53.18) | 112 (88.89) | |
| Age, median (IQR), yrs | 40 (35-46) | 41 (37-50) | 0.027 |
| Gender | | | |
| Female | 205 (17.14) | 20 (15.87) | 0.719 |
| Male | 991 (82.86) | 106 (84.13) | |
| Surgery at teaching hospital | | | |
| No | 246 (20.57) | 15 (11.90) | 0.020 |
| Yes | 950 (79.43) | 111 (88.10) | |
| Ever started HAART before surgery | | | |
| No | 326 (27.26) | 46 (36.51) | 0.028 |
| Yes | 870 (72.74) | 80 (63.49) | |
| Never an injection drug user | | | |
| No | 328 (27.42) | 26 (20.63) | 0.102 |
| Yes | 868 (72.58) | 100 (79.37) | |
| Ever AIDS diagnosis before surgery | | | |
| No | 838 (70.07) | 73 (57.94) | 0.005 |
| Yes | 358 (29.93) | 53 (42.06) | |
| Prior surgery | | | |
| Never | 706 (59.03) | 65 (51.59) | 0.001 |
| Surgery ≤ 6 months ago | 204 (17.06) | 38 (30.16) | |
| Surgery > 6 months ago | 286 (23.91) | 23 (18.25) | |
| Number of prior surgeries | | | |
| 0 | 706 (59.03) | 65 (51.59) | 0.231 |
| 1 | 275 (22.99) | 32 (25.40) | |
| ≥ 2 | 215 (17.98) | 29 (23.02) | |
| Vascular access surgery | | | |
| No | 1175 (98.24) | 123 (97.62) | 0.493 |
| Yes | 21 (1.76) | 3 (2.38) | |
| Adherence to antiretroviral therapy | | | |
| ≥95% | 505 (42.22) | 40 (31.75) | 0.023 |
| <95% | 691 (57.78) | 86 (68.25) | |
| CD4 cell count (cells/mm$^3$) within 90 days before surgery | | | |
| 200 | 647 (54.10) | 28 (22.22) | <0.001 |
| 50–200 | 301 (25.17) | 37 (29.37) | |
| ≤50 | 248 (20.74) | 61 (48.41) | |
| pVL within 90 days before procedure (log10) | | | |
| <3 | 461 (47.62) | 21 (27.63) | <0.001 |
| 3–4 | 142 (14.67) | 10 (13.16) | |
| 4–5 | 150 (15.50) | 10 (13.16) | |
| ≥5 (reference) | 215 (22.21) | 35 (46.05) | |
| Hemoglobin ≤ 120 g/L within 90 days before procedure | | | |
| No | 584 (59.41) | 17 (15.60) | <0.001 |
| Yes | 399 (40.59) | 92 (84.40) | |
| WBC count > 11 g/L within 90 days before procedure | | | |
| No | 928 (94.21) | 91 (82.73) | <0.001 |
| Yes | 57 (5.79) | 19 (17.27) | |

**TABLE 4.** Multivariate Analysis of Significant Factors Associated With 30-Day Postoperative Mortality in HIV/AIDS Patients (N = 855)

| Variable | AOR (95% CI) | P |
|---|---|---|
| Age (per 10-yr increase) | 1.83 (1.37–2.44) | <0.001 |
| Hemoglobin ≤ 120 g/L within 90 days before procedure | | |
| Yes vs No | 4.61 (2.24–9.51) | <0.001 |
| WBC count > 11 g/L within 90 days before procedure | | |
| Yes vs No | 5.73 (2.69–12.19) | <0.001 |
| Urgent/emergent admission | | |
| Yes vs No | 2.77 (1.24–6.21) | 0.013 |
| Prior surgery | | |
| Surgery ≤ 6 months ago | 2.01 (1.05–3.85) | 0.023 |
| Surgery > 6 months ago | 0.69 (0.33–1.46) | |
| Never (reference) | 1.00 | |
| CD4 cell count (cells/mm$^3$) within 90 days before surgery | | |
| 50–200 | 1.81 (0.87–3.75) | 0.036 |
| ≤50 | 2.69 (1.27–5.71) | |
| >200 (reference) | 1.00 | |

**TABLE 5.** Median Values of the HSMS for Various Factors Associated With 30-Day Postoperative Mortality

| Associated Factor | Median (IQR) of HSMS |
|---|---|
| Overall mortality | |
| Died (n = 64) | 18.71 (12.08–31.30) |
| Survived (n = 791) | 2.30 (0.77–8.47) |
| Age, yrs | |
| <30 (n = 51) | 1.30 (0.31–5.77) |
| 30 ≤ Age < 40 (n = 363) | 1.90 (0.52–7.66) |
| 40 ≤ Age < 50 (n = 299) | 3.10 (0.99–13.07) |
| ≥50 (n = 142) | 5.17 (1.68–16.70) |
| Hemoglobin | |
| Hemoglobin ≤ 120 g/L (n = 335) | 11.90 (6.38–20.52) |
| Hemoglobin > 120 g/L (n = 520) | 1.11 (0.56–2.32) |
| WBC count | |
| ≤11 g/L (n = 793) | 2.26 (0.77–8.55) |
| >11 g/L (n = 62) | 21.76 (9.36–36.84) |
| Urgent/emergent Admission | |
| Urgent/emergent admission (n = 446) | 8.95 (3.10–17.09) |
| Non Urgent/emergent admission (n = 409) | 0.82 (0.50–2.15) |
| Prior surgery | |
| No prior surgery | 2.07 (0.72–8.60) |
| Surgery ≤ 6 months ago | 7.32 (2.99–19.41) |
| Surgery > 6 months ago | 1.80 (0.66–7.35) |
| CD4 cell count | |
| CD4 ≤ 50 | 13.51 (7.06–23.52) |
| 50 ≤ CD4 ≤ 200 | 4.90 (1.90–11.90) |
| CD4 > 200 | 1.16 (0.54–3.76) |

We also found urgent or emergent hospital admission to be a strong predictor of postoperative mortality. Our findings support previously reported associations between urgent or emergent hospital admission and surgical intervention with increased morbidity and mortality in HIV/AIDS patients.[13,16,18] In immunocompromised individuals, the typical signs and symptoms of acute surgical conditions, including sepsis and obstruction, may not manifest until late in their disease course. Thus, surgeons caring for HIV/AIDS patients must be especially vigilant in their assessments to avoid missing either early or atypical surgical presentations and thus avoid putting these individuals at increased risk of developing complications and dying. Therefore, it is important to evaluate and treat HIV/AIDS patients with elective surgical conditions early to avoid complications necessitating urgent or emergent surgical interventions.

The effect of age on HIV patient surgical mortality has been previously reported in the trauma setting. Morrison et al[18] utilized the NTDB to examine the impact of HIV on outcomes in a group of 1379 HIV/AIDS trauma patients. They found that while overall mortality rates were not significantly different in the HIV-infected and HIV non-infected groups, even when stratifying by injury severity score and age, with the exception of patients who were 65 years or older. HIV-infected patients 65 years or older had a significantly higher mortality rate than their HIV noninfected age-matched counterparts (8.53% vs 15.63%; $P = 0.015$).[18] In the current study, we found age to be a significant predictor for postoperative mortality, with an AOR by multivariate analysis being 1.83 for each 10-year increment. Elderly patients tend to have more medical comorbidities and also have a more complex postoperative course, regardless of their HIV-infection status. Our results are consistent with currently published reports that suggest a 1.47-fold increase in mortality of HIV-infected individuals is associated with a 10-year increase in age at seroconversion.[18] Being aware of the associated increased risks of surgical intervention in the elderly HIV/AIDS patient population allows for more appropriate preoperative planning, counseling, and risk assessment, both for elective and emergent surgery.

Preoperative serum laboratory values were also found to be useful in predicting postoperative HIV/AIDS patient surgical mortality. A low WBC count has been previously reported to be a predictor of HIV/AIDS patient morbidity and mortality.[9,23,24] In the current study, we found that a WBC count more than 11g/L was predictive of postoperative mortality. In the study population, a more responsive WBC count may reflect the efficacy of HAART and thus not be observed in older published reports from the pre-HAART era. A low hemoglobin level has been previously reported to be a risk factor for surgical complications in HIV/AIDS patients,[17] and our findings are consistent with these observations. The laboratory values most commonly reported to be predictive of surgical morbidity and mortality in HIV/AIDS patients are their preoperative plasma viral load and their CD4 cell count.[6,16] These factors have also been previously reported to be useful predictors of outcome for nonsurgical HIV/AIDS patients in general.[25] Although our model did identify CD4 cell count as predictive of postoperative mortality, plasma viral load was not found to be useful. These observations suggest that optimization of CD4 cell count before elective surgical procedures may represent an important strategy to help reduce the risk of postoperative mortality.

The predictors of HIV/AIDS patient surgical mortality that were identified by multivariate logistic regression analysis were utilized to formulate an equation to predict the probability of postoperative mortality that we have termed the HSMS. By calculating the sensitivity and specificity of various cut points, we were able to select a score of 10 as the point with the highest positive predictive value for 30-day postoperative mortality. The HSMS represents a clinically applicable tool that may be calculated by utilizing readily available HIV/AIDS patient clinical and laboratory data that allows for accurate preoperative mortality risk estimation. If appropriately validated, the operative mortality risk calculated by the HSMS may be utilized for preoperative patient and family counseling, and to assist in treatment planning.

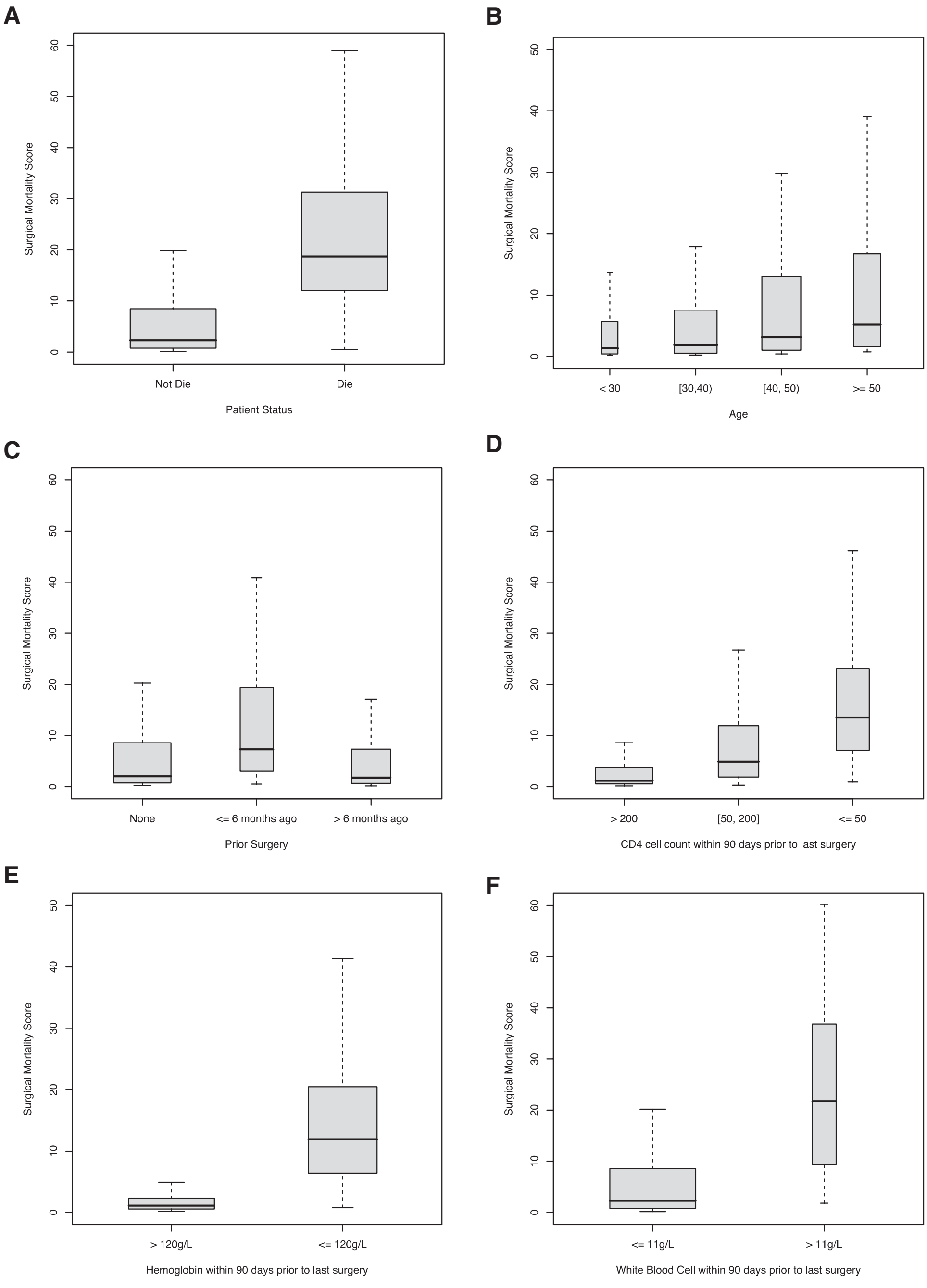


**FIGURE 1.** Distributions of HIV Surgical Mortality Scores for overall mortality (A), age (B), prior surgery (C), CD4 cell count (D), hemoglobin level (E), and white blood cell count (F).

Caution should be exercised when interpreting our results that are based upon a population-based registry of HIV-positive men and women ever receiving antiretroviral therapy. Although this registry was useful in providing our study with data from a large population-based cohort of HIV/AIDS patients undergoing surgery, the inherent limitations of a large retrospectively reviewed administrative database framework prevented a more detailed examination of each procedure on a specific case-by-case basis. We were therefore unable to comment on specific causes of death, and our review is limited by its primary endpoint being mortality. Complications not leading to death were also not identifiable in the database, and we believe a well-designed prospective clinical study is needed to identify specific information regarding postoperative morbidity. Another weakness of the current study is that it does not have a cohort of individuals not affected with HIV to serve as a basis for validation of the HSMS. Horberg et al[6] recently reported a retrospective study of surgical outcomes for a broad range of procedures in a cohort of 332 matched HIV-infected and HIV non-infected patients. They found that although

**TABLE 6.** Sensitivity and Specificity of HSMS Based on Different Score Cut Point Values

| Cut Point | Sensitivity | Specificity |
|---|---|---|
| 3 | 0.89 | 0.56 |
| 4 | 0.88 | 0.60 |
| 5 | 0.86 | 0.64 |
| 6 | 0.84 | 0.68 |
| 7 | 0.83 | 0.72 |
| 8 | 0.83 | 0.74 |
| 9 | 0.83 | 0.77 |
| 10 | 0.83 | 0.79 |
| 11 | 0.80 | 0.81 |
| 12 | 0.77 | 0.83 |
| 13 | 0.69 | 0.84 |
| 14 | 0.66 | 0.86 |
| 15 | 0.63 | 0.87 |
| 16 | 0.61 | 0.89 |
| 17 | 0.55 | 0.90 |
| 18 | 0.53 | 0.91 |

operative outcomes were comparable, the HIV infected patients had a higher incidence of pneumonia and a significantly higher 12-month mortality (3.0% vs 0.6%; $P = 0.04$).[6] Importantly, the HSMS must also be validated prospectively in any HIV/AIDS patient surgical populations for which it will be utilized, and as HAART continues to evolve the HSMS must also be validated in HIV/AIDS patients that are receiving newer drug treatments.

In summary, we reviewed 2305 operations carried out in 1322 HIV/AIDS patients in British Columbia, Canada, between 1995 and 2002 with an overall 30-day postoperative mortality of 9.5%. For the 855 patients who had complete laboratory data available, urgent/emergent admission, prior surgery, older age, a CD4 cell count less than 200 cells/mm$^3$, a hemoglobin level 120 g/L or less, and a WBC count more than 11 g/L, within the 90-days before the surgical procedure were predictive of an increased 30-day postoperative mortality in a multivariate model. In addition, if appropriately validated, our proposed HSMS could serve to estimate the probability of short-term postoperative death among HIV/AIDS patients.

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