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MAJOR ARTICLE

Impacts of Symptomatic HIV Infection on In-Hospital Cardiopulmonary Resuscitation Outcomes: A Population-Based Cohort Study in South Korea

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Background. The impact of HIV infection on survival outcomes after in-hospital cardiopulmonary resuscitation (ICPR) remains controversial. This study aimed to investigate the impacts of HIV infection on both short-term and long-term outcomes after ICPR.

Methods. This nationwide, population-based cohort study used data taken from the South Korean National Health Insurance Service database. All adult (≥18 years old) patients who experienced ICPR between January 1, 2010, and December 31, 2019, were included.

Results. A total of 298 676 adult patients who underwent ICPR were initially included in the analysis. Among them, 586 (0.2%) patients were assigned to the patients with symptomatic HIV infection (PWH) group, while 298 090 (99.8%) patients were assigned to the control group. After 1:10 propensity score (PS) matching, 586 patients in the PWH group and 5845 patients in the control group were included in the analysis. Logistic regression analysis after PS matching showed that the PWH group had a 20% lower live discharge rate after ICPR compared with the control group (odds ratio, 0.80; 95% CI, 0.65–0.97; $P = .024$). However, Cox regression analysis after PS matching showed that the risks of 6-month survival (hazard ratio [HR], 1.01; 95% CI, 0.93–1.11; $P = .768$) and 1-year survival (HR, 1.02; 95% CI, 0.93–1.11; $P = .702$) were not significantly different between the PWH and control groups.

Conclusions. Although the PWH group showed lower live discharge rates compared with the control group after ICPR, long-term survival outcomes from 6 months and 1 year were not significantly different.

Keywords. critical care; hospital mortality; ICU outcomes; mortality; resuscitation.

AIDS was first reported in the 1980s [1], and HIV-related deaths, such as from acute infection syndrome and opportunistic infection, have subsequently been reported [2]. According to a report by the Joint United Nations Programme on HIV/AIDS [3], 37.7 million people globally were living with HIV in 2020, and 1.5 million people were newly infected with HIV in 2020. Moreover, 36.3 million people have died due to AIDS-related diseases since the start of the epidemic [3]. However, antiretroviral therapy (ART) has greatly improved life expectancy in people with HIV infection [4]. As ART for patients with AIDS is not curative, the HIV/AIDS pandemic is currently one of the most important global health challenges [5, 6].

A systematic review and meta-analysis of 313 006 adult patients reported that 46% and 31% of adult patients with AIDS were hospitalized due to AIDS-related diseases and bacterial infection, respectively [7]. During hospitalization, patients with AIDS might experience in-hospital cardiopulmonary resuscitation (ICPR) due to in-hospital cardiac arrest (IHCA). The outcomes of ICPR in patients with AIDS can be poor due to their immunosuppressed condition. Moreover, ICPR in patients with AIDS requires medical staff to take precautions in the form of gloves, googles, hand hygiene, and safety devices to prevent needlestick injuries [8, 9]; this need for additional protection measures may affect the outcomes of ICPR in patients with AIDS. In 1988, Raviglione et al. reported that 1 (2.3%) of 43 patients with AIDS who underwent ICPR were eventually discharged alive [10]. The live discharge rate after ICPR in patients with AIDS (2.3%) was relatively lower than that in other patients (15.2% in a literature review) [11]. However, a previous study by Raviglione et al. analyzed a relatively small sample size of 43 patients from July 1, 1986, to June 30, 1987 [10], and the conditions of patients with HIV infection were different in the

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1980s–1990s compared with the 2010s due to advances in ART [12]. Recently, Lavi Oud reported that, in the United States, short-term survival (defined as absence of hospital mortality or discharge to hospice) after ICPR was lower in patients with HIV infection than in patients without HIV infection [13]. However, Lavi Oud did not compare long-term survival outcomes after ICPR according to HIV infection.

Therefore, this study aimed to investigate the impacts of symptomatic HIV infection on both short-term and long-term outcomes after ICPR during hospitalization using a nationwide registration database in South Korea. We hypothesized that patients with symptomatic HIV infection (PWH) might have poorer outcomes after ICPR than other patients who have undergone ICPR.

METHODS

Study Design, Setting, and Ethical Concerns

This nationwide population-based cohort study followed the Strengthening of the Reporting of Observational Studies in Epidemiology guidelines [14]. The institutional review board (IRB) of the Seoul National University Bundang Hospital approved the study protocol (IRB number: X-2011-651-901), and the National Health Insurance Service (NHIS) permitted data sharing after approval of the study protocol (NHIS-2021-1-266). The requirement for informed consent was waived by the IRB of the Seoul National University Bundang Hospital because data analysis was performed retrospectively in an anonymized form.

Data Source

The NHIS database was used in this study as it is a national health registration database. As the sole public insurance database system of South Korea, the NHIS database contains information regarding all disease diagnoses, drug prescriptions, and/or medical procedures. These registrations enabled patients to receive financial support from the government for treatment expenses. The International Statistical Classification of Disease and Related Health Problems, 10th Revision (ICD-10), codes were used to diagnose diseases.

Study Population

We initially screened all CPR cases in South Korea using the prescription code of CPR between January 1, 2010, and December 31, 2019. Next, we excluded cases of CPR due to out-of-hospital cardiac arrest; all ICPR cases due to IHCA were selected for this study.

For any patient, all cases of ICPR per day were counted as 1 ICPR case. For example, if a patient received ICPR 3 times on a certain day during the study period, it was considered 1 ICPR case. This was because some patients experienced ICPR multiple times during a short duration in the same day and thus might bias the results. In our database, some patients experienced ICPR over 10 times in the same day. This could have caused a significant bias.

However, if a patient received ICPR 2 or more times on different days during the study period, only the first ICPR at the earliest date was included in this study. Therefore, if a patient received ICPR 2 times on January 3, 2010, and January 26, 2010, the first ICPR case on January 3, 2010, was considered, and the ICPR on January 26, 2010, was excluded from the final analysis. The homogeneity of the study population improved with this exclusion as a patient's physical condition might worsen at the later date of ICPR as opposed to the earlier date. Pediatric patients under 18 years old were also excluded from the analysis. Accurate death dates for all patients included in the study population were extracted and collected until April 30, 2021.

Exposure Variable: Symptomatic HIV Infection

ICD-10 codes B20–B24 were used for the extraction of PWH among the study population. The patients who were diagnosed with symptomatic HIV infection by ICD-10 codes within 1 year before the date of ICPR were defined as the PWH group, while the other patients were considered the control group in this study. In South Korea, patients with HIV infection should be registered in the NHIS database to receive financial coverage for their treatment. Specifically, ART for HIV infection and hospitalization for the treatment of complications due to HIV infection (such as opportunistic infections) are provided free of charge by the government in South Korea [15]. In general, standard precautions (gloves, googles, hand hygiene, and safety devices to prevent needlestick injuries) were emphasized to the medical staff when they performed ICPR in patients with AIDS.

End Points

The primary end point of this study was live discharge after the ICPR. Secondary end points were survival at 6 months and 1 year after ICPR.

Covariates

Age and sex were collected as the physical covariates. Employment status, residence, and household income level at the time of ICPR were collected to reflect the socioeconomic status of the study population. Self-employed patients were not considered employed, and residences were extracted using the ZIP codes of their homes at the time of hospital admission. National household income levels at the time of ICPR were registered in the NHIS database to determine insurance premiums for the Korean population, and the data were divided into 4 groups using the quartile ratio. The main diagnoses at the time of the ICPR were collected and divided into 4 groups according to ICD-10 codes: cardiovascular disease (I00–I99), respiratory disease (J00–J99), cancer (C00–D49), and others. The main diagnosis at the time of ICPR was determined by the NHIS after hospital discharge or death as the disease that required

the greatest treatment or examination during the patient's hospitalization. The admitting departments at the time of ICPR were identified and classified into internal medicine (IM) and non-IM groups. The duration of the ICPR was classified into 1 of 5 groups: <15 minutes, 15–30 minutes, 30–45 minutes, 45–60 minutes, and >60 minutes. The hospitals where the ICPRs were performed during the study period were classified into 3 groups: tertiary general hospitals, general hospitals, and other hospitals. Moreover, hospitals were divided into 2 groups according to the total number of hospital beds, including those in intensive care units, namely <1000 beds and ≥1000 beds. Annual ICPR case volumes were calculated based on the hospitals where the ICPRs were performed using the following formula: total ICPR cases among adult patients / 10 years. To reflect the comorbidity status of all patients, the Charlson comorbidity index (CCI) score was calculated using ICD-10 codes in the NHIS database registered no more than 1 year before the ICPR, as shown in Supplementary Table 1. Underlying disability at the time of ICPR was also extracted as a covariate. We recorded data on 15 types of disabilities, including physical disabilities, brain lesion disabilities, visual disturbances, hearing disturbances, speech disabilities, autism, intellectual disorder, mental disorder, renal disorder, heart diseases, respiratory disorders, hepatopathy, intestinal fistulae, urinary fistulae, and epilepsy. Additionally, each disability was assigned 1 of 6 grades based on severity; we grouped the severity grades into 2 groups (1–3, severe disability; and 4–6, mild to moderate disability).

Statistical Analysis

The clinicopathological characteristics of all patients are presented as mean values with standard deviations for continuous variables and numbers with percentages for categorical variables. We used propensity score (PS) matching to adjust for covariates between the PWH group and the control group. PS matching was performed using the nearest neighbor method with a 1:10 ratio without replacement and a caliper width of 0.15 [16]. Logistic regression analysis was performed to calculate PS as a logistic model, and all covariates were included in the PS model. We determined an adequate balance of all covariates using an absolute standardized difference (ASD) ≤0.1. Next, we performed logistic regression analysis to examine the odds of live discharge after ICPR in the PWH group compared with the control group in the PS-matched cohort. We also performed Cox regression analysis to examine the hazard ratios of 6-month and 1-year survival after ICPR in the PWH group compared with the control group in the PS-matched cohort. The results of the logistic regression analyses were presented as odds ratios (ORs) with 95% CIs, while those of Cox regression analyses were presented as hazard ratios (HRs) with 95% CIs. Moreover, the overall survival times after ICPR between the PWH group and the control group are presented using Kaplan-Meier curves, and median survival times with 95% CIs in the 2 groups were compared using the log-rank test.

As a sensitivity analysis, we constructed a multivariable logistic model for live discharge after ICPR in the entire cohort to examine whether the results obtained in the PS-matched cohort were generalizable to the entire cohort. All covariates were included in the multivariable model for adjustment, except for CCI due to the multicollinearity with other underlying individual diseases that were used to calculate CCI. In addition, subgroup analysis of live discharge according to year of ICPR was performed using a multivariable logistic regression model, because health conditions in the PWH group may have improved from 2010 to 2019 due to development of ART [4]. Moreover, subgroup analyses according to CCI and age were performed, because comorbidity status and age might affect outcomes after ICPR in the PWH group. All patients were divided into 3 groups according to CCI (0–6, 7–10, and ≥11 points) and 4 groups according to age (18–40, 41–55, 56–70, and ≥71 years old). The Hosmer-Lemeshow test was used to confirm that the goodness of fit in the multivariate model was appropriate. There was no issue of multicollinearity between variables in the multivariable model using the criteria of variance inflation factors <2.0. R software (version 4.0.3; R Foundation for Statistical Computing, Vienna, Austria) was used for all analyses, and a *P* value <.05 was considered statistically significant.

RESULTS

Study Population

From January 1, 2010, to December 31, 2019, there were 478 836 CPR cases in South Korea. A total of 140 046 CPR cases due to out-of-hospital cardiac arrest were excluded from the analysis. Next, 31 122 cases in which a patient received ICPR more than once on different days during the study period and 8992 pediatric cases (under 18 years of age) were excluded from the final analysis. Finally, the remaining 298 676 adult patients who underwent ICPR were included in the analysis. Among them, 586 (0.2%) were in the PWH group, while 298 090 (99.8%) patients were in the control group. After 1:10 PS matching, 586 patients in the PWH group and 5845 patients in the control group were included in the analysis, as shown in Figure 1. The clinicopathologic characteristics of the PWH group and the control group before and after PS matching are presented in Table 1. All ASDs of covariates between the 2 groups were below 0.1, suggesting that the 2 groups had adequate balance through PS matching.

Survival Analysis

Table 2 shows the results of the survival analysis before and after PS matching. After PS matching, 24.2% (142 of 586) of the patients in the PWH group were alive after ICPR, while 28.6% (1674 of 5845) of the patients in the control group were also alive

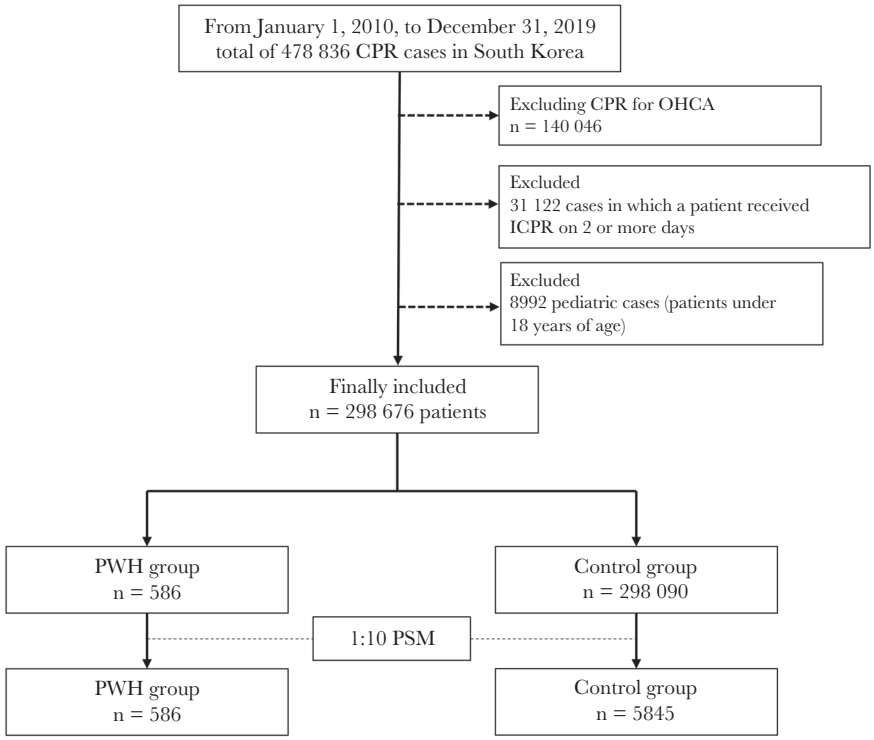

Figure 1. Flowchart depicting patient selection process. Abbreviations: CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; PSM, propensity score matching; PWH, patients with symptomatic HIV infection.

after ICPR. In the logistic regression analysis, the PWH group showed a 20% lower live discharge rate after ICPR than the control group (OR, 0.80; 95% CI, 0.65–0.97; $P = .024$). However, the risks associated with the 6-month survival rate (HR, 1.01; 95% CI, 0.93–1.11; $P = .768$) and 1-year survival rate (HR, 1.02; 95% CI, 0.93–1.11; $P = .702$) were not significantly different between the 2 groups. Figure 2 shows the overall survival time after ICPR in the 2 groups using Kaplan-Meier curves in the PS-matched cohort. The median survival time after ICPR in the PWH group was 8 days (95% CI, 6.7–9.7), while that in the control group was 6 days (95% CI, 5.5–6.6; $P = .929$). Table 3 shows the results of the multivariable logistic regression model for live discharge after ICPR among the entire cohort. The PWH group showed a 22% lower live discharge rate after ICPR than the control group (OR, 0.78; 95% CI, 0.64–0.95; $P = .012$). Supplementary Tables 2, 3, and 4 show the results of subgroup analyses according to year of ICPR, age, and CCI. All subgroups showed no statistically significant differing trends in live discharge between the PWH group and the control group (all $P > .05$).

DISCUSSION

In this study, using a nationwide database in South Korea, we showed that PWH were associated with a lower live discharge rate after ICPR than the control group. However, long-term survival outcomes at 6 months and 1 year after ICPR did not differ between the PWH group and the control group. These associations were applied to both the PS-matched cohort and the entire cohort using multivariable adjustment. This is the first study to show both short-term and long-term outcomes after ICPR in PWH compared with the control group.

A similar study by Lavi Oud reported that the incidence of ICPR was similar among those hospitalized with and without HIV infection; however, HIV-infected patients have been shown to have lower short-term survival rates in the United States [13]. In terms of short-term survival outcomes, Oud reported findings similar to those of our study. Oud analyzed 437 and 54 135 patients with and without HIV, respectively, who experienced ICPR during hospitalization in the United States [13], while we analyzed 586 and 298 090 subjects in the PWH group and the control group, respectively, who experienced ICPR during hospitalization in South Korea. The findings from our study and those of Lavi Oud contradict those of a previous study by Mongardon et al., which reported that ICU mortality after cardiac arrest was not significantly affected by HIV infection among 99 patients [17]. In addition to the study by Lavi Oud, our study analyzed a large sample size using a national registration database in South Korea, which might be more robust than the study by Mongardon et al. [17]. Most importantly, we first reported that although short-term outcomes after ICPR might be worse in patients with AIDS, long-term survival outcomes after ICPR were not significantly affected by HIV infection.

Table 1. Clinicopathologic Characteristics of the PWH and Control Groups Before and After PS Matching

Variable	Before PS Matching			After PS Matching		
	PWH (n = 586)	Control (n = 298 090)	ASD	PWH (n = 586)	Control (n = 5845)	ASD
Age	62.7 (15.6)	69.9 (15.2)	0.463	62.7 (15.6)	62.7 (15.6)	0.009
Sex, male	423 (72.2)	179 971 (60.4)	0.263	423 (72.2)	4175 (71.4)	0.017
Having a job at ICPR	253 (43.2)	152 800 (51.3)	0.163	253 (43.2)	2571 (44.0)	0.016
Residence at ICPR						
Urban area	273 (46.6)	128 784 (43.2)		273 (46.6)	2748 (47.0)	
Rural area	313 (53.4)	169 306 (56.8)	0.068	313 (53.4)	3097 (53.0)	0.010
Household income level at ICPR						
Q1 (lowest)	219 (37.4)	93 559 (31.4)		219 (37.4)	2159 (36.9)	
Q2	107 (18.3)	46 119 (15.5)	0.072	107 (18.3)	1065 (18.2)	<0.001
Q3	124 (21.2)	58 504 (19.6)	0.038	124 (21.2)	1220 (20.9)	0.006
Q4	128 (21.8)	94 296 (31.6)	0.237	128 (21.8)	1320 (22.6)	0.017
Unknown	8 (1.4)	5612 (1.9)	0.045	8 (1.4)	81 (1.4)	0.002
Main diagnosis at ICPR						
Cardiovascular disease	151 (25.8)	115 008 (38.6)		151 (25.8)	1553 (26.6)	
Respiratory disease	58 (9.9)	41 901 (14.1)	0.139	58 (9.9)	565 (9.7)	0.009
Cancer	48 (8.2)	33 450 (11.2)	0.110	48 (8.2)	479 (8.2)	0.001
Other	329 (56.1)	107 731 (36.1)	0.403	329 (56.1)	3248 (55.6)	0.009
Admitting department						
IM	401 (68.4)	166 378 (55.8)		401 (68.4)	3944 (67.5)	
Non-IM	185 (31.4)	131 712 (44.2)	0.271	185 (31.4)	1901 (32.5)	0.019
Duration of ICPR						
	258 (44.0)	135 407 (45.4)		258 (44.0)	2609 (44.6)	
15–30	192 (32.8)	86 342 (29.0)	0.081	192 (32.8)	1895 (32.4)	0.007
30–45	76 (13.0)	40 772 (13.7)	0.021	76 (13.0)	716 (12.2)	0.022
45–60	34 (5.8)	19 193 (6.4)	0.027	34 (5.8)	331 (5.7)	0.005
>60	26 (4.4)	16 376 (5.5)	0.051	26 (4.4)	294 (5.0)	0.028
Type of hospital						
Tertiary general hospital	246 (42.0)	112 044 (37.6)		246 (42.0)	2448 (41.9)	
General hospital	293 (50.0)	153 027 (51.3)	0.027	293 (50.0)	2956 (50.6)	0.011
Other hospital	47 (8.0)	33 019 (11.1)	0.112	47 (8.0)	441 (7.5)	0.018
Total hospital bed number						
<1000	480 (81.9)	252 704 (84.8)		480 (81.9)	4776 (81.7)	
≥1000	106 (18.1)	45 386 (15.2)	0.074	106 (18.1)	1069 (18.3)	0.006
Annual case volume of ICPR						
0–56	91 (15.5)	74 720 (25.1)		91 (15.5)	911 (15.6)	
57–194	242 (41.3)	75 965 (25.5)	0.321	242 (41.3)	2364 (40.4)	0.015
194–276	119 (20.3)	72 794 (24.4)	0.102	119 (20.3)	1168 (20.0)	0.009
277	134 (22.9)	74 611 (25.0)	0.051	134 (22.9)	1402 (24.0)	0.026
Underlying disability						
Mild to moderate	61 (10.4)	35 235 (11.8)	0.046	61 (10.4)	607 (10.4)	0.002
Severe	129 (22.0)	51 559 (17.3)	0.114	129 (22.0)	1300 (22.2)	0.007
CCI at ICPR	6.9 (4.4)	6.0 (3.9)	0.208	6.9 (4.4)	6.9 (4.1)	0.009
Myocardial infarction	131 (22.4)	54 026 (18.1)	0.102	131 (22.4)	1299 (22.2)	0.002
Congestive heart failure	250 (42.7)	117 347 (39.4)	0.066	250 (42.7)	2429 (41.6)	0.021
Peripheral vascular disease	138 (23.5)	70 417 (23.6)	0.002	138 (23.5)	1386 (23.7)	0.004
Cerebrovascular disease	217 (37.0)	112 540 (37.8)	0.015	217 (37.0)	2126 (37.2)	0.005
Dementia	106 (18.1)	67 651 (22.7)	0.120	106 (18.1)	1061 (18.2)	<0.001
Chronic pulmonary disease	356 (60.8)	165 692 (55.6)	0.106	356 (60.8)	3549 (60.7)	<0.001
Rheumatic disease	51 (8.7)	19 482 (6.5)	0.077	51 (8.7)	520 (8.9)	<0.001
Peptic ulcer disease	250 (42.7)	116 269 (39.0)	0.074	250 (42.7)	2476 (42.4)	0.006
Mild liver disease	402 (68.6)	144 537 (48.5)	0.433	402 (68.6)	3796 (64.9)	0.030
Diabetes without chronic complication	386 (65.9)	173 908 (58.3)	0.159	386 (65.9)	3796 (64.9)	0.019
Diabetes with chronic complication	172 (29.4)	69 728 (23.4)	0.131	172 (29.4)	1735 (29.7)	0.008
Hemiplegia or paraplegia	180 (30.7)	80 907 (27.1)	0.077	180 (30.7)	1788 (30.6)	0.003
Renal disease	174 (29.7)	51 400 (17.2)	0.272	174 (29.7)	1707 (29.2)	0.008

Table 1. Continued

Variable	Before PS Matching			After PS Matching		
	PWH (n = 586)	Control (n = 298 090)	ASD	PWH (n = 586)	Control (n = 5845)	ASD
Cancer	193 (32.9)	82 940 (27.8)	0.109	193 (32.9)	1901 (32.5)	0.008
Moderate or severe liver disease	41 (7.0)	19 468 (6.5)	0.018	41 (7.0)	410 (7.0)	<0.001
Metastatic cancer	43 (7.3)	24 416 (8.2)	0.032	43 (7.3)	430 (7.4)	0.001
Year of ICPR						
2010	38 (6.5)	24 448 (8.2)		38 (6.5)	394 (6.7)	
2011	29 (4.9)	24 140 (8.1)	0.145	29 (4.9)	321 (5.5)	0.024
2012	34 (5.8)	24 572 (8.2)	0.104	34 (5.8)	359 (6.1)	0.014
2013	57 (9.7)	24 035 (8.1)	0.056	57 (9.7)	544 (9.3)	0.014
2014	31 (5.3)	23 665 (7.9)	0.118	31 (5.3)	290 (5.0)	0.015
2015	35 (6.0)	23 776 (8.0)	0.085	35 (6.0)	354 (6.1)	0.003
2016	57 (9.7)	35 823 (12.0)	0.077	57 (9.7)	569 (9.7)	<0.001
2017	70 (11.9)	35 824 (12.0)	0.002	70 (11.9)	670 (11.5)	0.015
2018	97 (16.6)	41 512 (13.9)	0.071	97 (16.6)	998 (17.1)	0.014
2019	138 (23.5)	40 295 (13.5)	0.236	138 (23.5)	1346 (23.0)	0.009

Abbreviations: ASD, absolute value of standardized mean difference; CCI, Charlson comorbidity index; ICPR, in-hospital cardiopulmonary resuscitation; IM, internal medicine; PS, propensity score; PWH, patients with symptomatic HIV infection.

PWH can fall critically ill and be admitted to intensive care units (ICUs). A recent study by Azoulay et al. reported that acute respiratory failure, neurological disorders, and sepsis remain the main conditions that lead HIV-infected patients to the ICU [18]. Moreover, ICU admission due to acute kidney injury and liver disease among HIV-infected patients has increased [18]. Therefore, the management of critically ill patients with HIV infection, especially those in the ICU, is a potentially important issue. IHCA is a major contributor to mortality and morbidity among critically ill patients in the ICU [19], and the outcome of ICPR in PWH might affect their survival outcome. Our study suggested that compared with other critically ill patients who have undergone ICPR, PWH might have a more fatal outcome.

Dysfunction of the immune system is common in critically ill patients, and it can modulate the immune response and worsen patient morbidity and mortality, particularly in sepsis [20]. Moreover, severe lymphopenia has been described in ~30% of patients admitted to the ICU with severe sepsis or septic shock and has been related to high plasma levels of tumor necrosis

Table 2. Survival Analysis Before and After PSM

Variable	Event, No. (%)	LR or Cox Regression Analysis	*P* Value
Discharge alive before PSM			
Control	78 041/298 090 (26.2)	1	
PWH group	142/586 (24.2)	0.90 (0.75–1.09)	.284
6-mo survival before PSM			
Control	268 846/298 090 (90.2)	1	
PWH group	527/586 (89.9)	0.87 (0.80–0.95)	.001
1-y survival before PSM			
Control	272 291/298 090 (91.3)	1	
PWH group	535/586 (91.3)	0.87 (0.80–0.95)	.002
Live discharge after PSM			
Control	1674/5845 (28.6)	1	
PWH group	142/586 (24.2)	0.80 (0.65–0.97)	.024
6-mo survival after PSM			
Control	5054/5845 (86.5)	1	
PWH group	527/586 (89.9)	1.01 (0.93–1.11)	.768
1-y survival after PSM			
Control	5139/5845 (87.9)	1	
PWH group	535/586 (91.3)	1.02 (0.93–1.11)	.702

All results were derived from univariable analysis after PSM. The results of logistic regression for discharge alive are presented as ORs with 95% CIs. The results of Cox regression for 6-month and 1-year survival are presented as HRs with 95% CIs.

Abbreviations: LR, logistic regression; OR, odds ratio; PSM, propensity score matching; PWH, patients with symptomatic HIV infection.

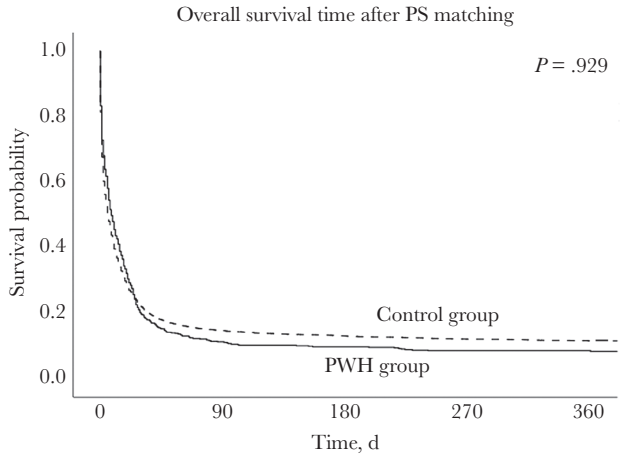

Figure 2. Overall survival time after ICPR in the PWH group and the control group using Kaplan-Meier curves after PS matching. Abbreviations: ICPR, in-hospital cardiopulmonary resuscitation; PS, propensity score; PWH, patients with symptomatic HIV infection.

factor–α, interleukin (IL)-6, and IL-10 [21]. Lymphopenia during sepsis was also associated with features of immunosuppression, such as an increased risk of hospital-acquired infections, and was also an independent predictor of poor outcome [22]. In patients with AIDS, lymphopenia could develop due to antibody-dependent cytotoxicity, and 80% of adults and only 50% of children with AIDS have been reported to be lymphopenic [23, 24]. Furthermore, the immunosuppressive peptide of HIV-1 inhibits T- and B-lymphocyte stimulation, and lymphopenia can occur due to the immunosuppressive effect of HIV infection [25]. A previous study reported that lymphopenia was common in patients with cardiac arrest and was associated with poor outcomes after CPR [26]. From these perspectives, it is possible that the immunosuppressive status in PWH with lymphopenia might contribute to the lower live discharge rate than in the control group after ICPR in this study.

Interestingly, long-term survival at 1 year after ICPR was not significantly different between the PWH and control groups in this study. In a retrospective cohort study in France, short- and long-term survival outcomes were related to acute illness severity and immunovirological status at ICU admission in HIV-infected patients [27]. As the South Korean government supports all financial burdens for treatment of HIV infection including ART [15], all PWH continuing ART after ICPR are still supported by the national government if they survive ICPR. Therefore, on continuing ART, our data show that if PWH survive ICPR and are discharged alive from the hospital, they can achieve similar long-term survival outcomes as those without HIV infection.

HIV is a known risk factor for cardiovascular events [28], which include acute myocardial infarction, heart failure, sudden cardiac death, peripheral arterial disease, and stroke [29]. As cardiovascular disease is one of the most common causes of death [30], the PWH group in this study was at potentially

Table 3. Multivariable Logistic Regression Model for Live Discharge After ICPR Among the Entire Cohort

Variable	OR (95% CI)	*P* Value
PWH group (vs control group)	0.78 (0.64–0.95)	.012
Age	0.98 (0.98–0.98)	<.001
Sex, male (vs female)	1.02 (1.00–1.04)	.042
Having a job at ICPR (vs no job)	1.04 (1.02–1.06)	<.001
Residence at ICPR		
Urban area (reference group)	1	
Rural area	0.92 (0.91–0.94)	<.001
Household income level at ICPR		
Q1 (lowest; reference group)	1	
Q2	1.07 (1.04–1.10)	<.001
Q3	1.09 (1.07–1.12)	<.001
Q4	1.10 (1.08–1.13)	<.001
Unknown	1.09 (1.03–1.17)	.006
Main diagnosis at ICPR		
Cardiovascular disease (reference group)	1	
Respiratory disease	1.36 (1.33–1.38)	<.001
Cancer	0.95 (0.93–0.98)	.001
Other	0.69 (0.67–0.72)	<.001
Admitting department		
Non-IM (reference group)	1	
IM	0.97 (0.95–0.99)	.001
Duration of ICPR		
ÿ	1	
15-30	4.01 (3.83–4.20)	<.001
30-45	1.77 (1.69–1.86)	<.001
45-60	1.20 (1.14–1.27)	<.001
	1.03 (0.97–1.10)	.300
Type of hospital		
Tertiary general hospital (reference group)	1	
General hospital	0.62 (0.61–0.64)	<.001
Other hospital	0.73 (0.70–0.76)	<.001
Total hospital bed number		
ÿ	1	
≥1000	1.10 (1.07–1.13)	<.001
Annual case volume of ICPR		
0–56 (reference group)	1	
57–194	0.89 (0.87–0.92)	<.001
194–276	0.88 (0.86–0.92)	<.001
277	0.55 (0.53–0.578)	<.001
Underlying disability		
Mild to moderate (vs no disability)	1.01 (0.98–1.03)	.710
Severe (vs no disability)	1.05 (1.03–1.08)	<.001
Myocardial infarction	1.23 (1.20–1.26)	<.001
Congestive heart failure	1.12 (1.10–1.14)	<.001
Peripheral vascular disease	1.07 (1.04–1.09)	<.001
Cerebrovascular disease	0.97 (0.95–0.99)	.001
Dementia	1.00 (0.98–1.02)	.985
Chronic pulmonary disease	1.37 (1.34–1.39)	<.001
Rheumatic disease	0.93 (0.90–0.96)	<.001
Peptic ulcer disease	1.15 (1.13–1.17)	<.001
Mild liver disease	1.12 (1.10–1.14)	<.001
Diabetes without chronic complication	1.14 (1.12–1.14)	<.001
Diabetes with chronic complication	0.96 (0.93–0.99)	.026
Hemiplegia or paraplegia	1.12 (1.09–1.16)	<.001
Renal disease	0.91 (0.89–0.94)	<.001
Cancer	0.94 (0.92–0.97)	<.001
Moderate or severe liver disease	0.54 (0.52–0.56)	<.001

Table 3. Continued

Variable	OR (95% CI)	*P* Value
Metastatic cancer	0.76 (0.73–0.79)	<.001
Year of ICPR		
2010 (reference group)	1	
2011	1.00 (0.96–1.04)	.869
2012	0.99 (0.95–1.04)	.755
2013	0.87 (0.83–0.91)	<.001
2014	0.88 (0.84–0.92)	<.001
2015	0.87 (0.83–0.91)	<.001
2016	0.90 (0.87–0.94)	<.001
2017	0.88 (0.84–0.91)	<.001
2018	0.82 (0.79–0.85)	<.001
2019	0.86 (0.83–0.89)	<.001

Abbreviations: ICPR, in-hospital cardiopulmonary resuscitation; IM, internal medicine; OR, odds ratio; PWH, patients with symptomatic HIV infection.

higher risk for adverse cardiovascular events compared with the control group, and this might have had a negative effect on the live discharge rate in the PWH group after ICPR.

There are several limitations to this study. First, the immune status or disease severity of HIV infection in the PWH group was not evaluated in this study. This is because the CD4 cell count among patients with AIDS was not available in this study. Second, we cannot access data such as the return of spontaneous circulation after ICPR because there is no ICD-10 code for this in the NHIS database. Third, some important information, such as smoking history, alcohol consumption, and body mass index, was not used in this study due to the limitations of the NHIS database. Lastly, although the data in this study included all ICPR cases across the country, the data were only from South Korea. Therefore, it may be difficult to generalize our findings to other countries because there are different medical systems and cultures. In particular, there have been global variations in mortality in adult patients with HIV infection after initiating antiretroviral treatment [31].

In conclusion, PWH were associated with a lower live discharge rate than those without HIV infection after ICPR. However, long-term survival outcomes up to 6 months and 1 year were not significantly affected by HIV infection. Future studies are needed to improve the live discharge rate after ICPR in PWH.

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Patient consent. The institutional review board (IRB) of Seoul National University Bundang Hospital approved the study protocol (IRB number: X-2011-651-901), and the National Health Insurance Service (NHIS) permitted data sharing after approval of the study protocol (NHIS-2021-1-266). The requirement for informed consent was waived by the IRB of Seoul National University Bundang Hospital because data analysis was performed retrospectively in an anonymized form.

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