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Timing of Pericardiocentesis and In-Hospital Outcomes in Cancer Patients With Cardiac Tamponade: A Retrospective Cross-Sectional National Inpatient Sample Study

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Abstract

Background

Cardiac tamponade is a life-threatening complication in patients with cancer and often prompts urgent pericardial drainage. Contemporary data on how the timing of pericardiocentesis relates to outcomes in this population remain limited.

Methods

We performed a retrospective cross-sectional study of the U.S. National Inpatient Sample from 2016 to 2022. Adult hospitalizations with cardiac tamponade and a concomitant cancer diagnosis that underwent pericardiocentesis or pericardial drainage were included. Timing was categorized as early drainage (hospital day 0) or delayed drainage (hospital day ≥ 1). The primary outcome was in-hospital mortality. Secondary outcomes were length of stay and inflation-adjusted total hospital charges. Survey-weighted analyses generated national estimates, and multivariable survey-weighted logistic regression was used to estimate adjusted odds ratios for mortality.

Results

We identified 2255 cancer-related hospitalizations with cardiac tamponade undergoing pericardiocentesis or pericardial drainage; 1140 (50.6%) received early drainage and 1115 (49.4%) received delayed drainage. Respiratory cancers were the most common malignancy group (28.3%), followed by breast cancer (8.2%). Delayed drainage was associated with higher unadjusted in-hospital mortality than early drainage (14.8% vs 8.8%; $p = 0.052$), a longer mean length of stay (10.12 vs 7.04 days; $p < 0.01$), and higher mean inflation-adjusted hospital charges (174178 vs 113922.9; $p < 0.01$). After adjustment, delayed drainage remained independently associated with increased odds of in-hospital death (adjusted odds ratio 2.21; 95% confidence interval 1.11–4.41; $p = 0.025$).

Conclusions

Among cancer-related hospitalizations complicated by cardiac tamponade, delayed pericardiocentesis was independently associated with higher in-hospital mortality. These findings support timely drainage and justify prospective studies to identify workflow barriers and improve acute cardio-oncology care.

Trial registration:

Not applicable.

Background

Cardiac tamponade is a time-critical hemodynamic emergency in which rising intrapericardial pressure restricts ventricular filling, reduces stroke volume and cardiac output, and can rapidly progress to shock and death without prompt intervention (1). Among clinically significant causes of pericardial effusion and tamponade, cancer remains an important driver, through metastatic involvement, direct tumor extension, treatment-related injury, or coexisting systemic illness (1–8). Respiratory malignancies are frequently represented in malignant pericardial disease cohorts, and breast cancer is also commonly encountered (4–8).

Pericardiocentesis is the definitive and potentially reversible treatment for tamponade physiology. Although current guidance emphasizes urgent decompression, real-world drainage timing may still be influenced by diagnostic delay, hemodynamic uncertainty, thrombocytopenia or coagulopathy, anticoagulation status, consultant availability, and procedural access (9–13). In cancer populations, these competing clinical considerations may be especially relevant because advanced malignancy, bleeding risk, and goals-of-care discussions often coexist at presentation.

Evidence evaluating the relationship between drainage timing and in-hospital outcomes in cancer patients with cardiac tamponade remains limited. We therefore used the U.S. National Inpatient Sample (NIS) to examine cancer-related hospitalizations complicated by cardiac tamponade in which pericardiocentesis or pericardial drainage was performed, and to compare outcomes between early drainage on hospital day 0 and delayed drainage on hospital day 1 or later.

Methods

Study design and data source

We performed a retrospective cross-sectional study using the Healthcare Cost and Utilization Project (HCUP) NIS from 2016 through 2022. The NIS is a nationally representative, all-payer inpatient discharge database. Diagnoses are coded using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM), and inpatient procedures are coded using the International Classification of Diseases, Tenth Revision, Procedure Coding System (ICD-10-PCS). The unit of analysis was the hospitalization.

Study population

We included adult hospitalizations (age ≥ 18 years) with cardiac tamponade recorded as a principal or secondary diagnosis (ICD-10-CM I31.4) and a concomitant cancer diagnosis identified using HCUP Clinical Classifications Software Refined cancer categories in any diagnosis field. We required that pericardiocentesis or pericardial drainage be performed during the same admission, identified by ICD-10-

PCS pericardial cavity drainage codes in any procedure field: 0W9D30Z, 0W9D3ZX, 0W9D3ZZ, 0W9D40Z, 0W9D4ZX, and 0W9D4ZZ. Admissions classified as non-melanoma skin cancer were excluded.

Exposure and outcomes

Pericardiocentesis timing was determined using the NIS days-from-admission-to-procedure variable and defined according to the earliest qualifying pericardial drainage procedure day across all listed procedures. Early drainage was defined as hospital day 0, and delayed drainage as hospital day 1 or later. The primary outcome was in-hospital mortality. Secondary outcomes were hospital length of stay and total hospital charges. Charges were inflation-adjusted using Bureau of Labor Statistics price indices. Comorbidities were identified using HCUP Elixhauser comorbidity software.

Statistical analysis

All analyses used survey-weighted methods to account for the complex sampling design of the NIS and to generate national estimates. Continuous variables were summarized as survey-weighted means with standard errors, and categorical variables as survey-weighted percentages. In-hospital mortality was compared between drainage-timing groups using survey-weighted cross-tabulations. Length of stay and inflation-adjusted total charges were compared using survey-weighted regression methods. We then fitted a multivariable survey-weighted logistic regression model with in-hospital mortality as the dependent variable. Drainage timing was the primary exposure, and covariates included age, sex, race or ethnicity, hypertension, diabetes mellitus, and selected clinically relevant Elixhauser comorbidity indicators. Results are reported as adjusted odds ratios (aORs) with 95% confidence intervals (CIs). A two-sided p value < 0.05 was considered statistically significant. Analyses were performed using Stata/MP 18.0 (StataCorp, College Station, TX, USA).

Results

We identified 2255 cancer-related hospitalizations complicated by cardiac tamponade in which pericardiocentesis or pericardial drainage was performed. Of these, 1140 (50.6%) underwent early drainage on hospital day 0 and 1115 (49.4%) underwent delayed drainage on hospital day 1 or later. Selected baseline characteristics are shown in Table 1, and the full baseline table is provided in Additional file 1. The mean age was 59.25 years in the early-drainage group and 56.66 years in the delayed-drainage group ($p = 0.07$). Female sex distribution was similar between groups (49.56% vs 50.90%; $p = 0.775$). Overall race or ethnicity distribution did not differ significantly ($p = 0.157$). Diabetes mellitus was more common in the early-drainage group (22.81% vs 14.35%; $p = 0.016$), whereas most other selected comorbidities were similar between groups.

Table 1

Selected baseline characteristics by drainage timing Values are survey-weighted means (SE) or percentages. The full baseline characteristics table is provided in Additional file 1.

Characteristic	Early drainage (day 0) (N = 1140)	Delayed drainage (day ≥ 1) (N = 1115)	p value
Age, mean (SE)	59.25 (0.98)	56.66 (1.05)	0.07
Female sex	49.56%	50.90%	0.775
Race or ethnicity			0.157
White	56.95%	59.45%	
African American	18.83%	13.36%	
Hispanic	14.35%	11.06%	
Asian or Pacific Islander	5.38%	6.91%	
Native American	0.00%	0.92%	
Other	4.48%	8.29%	
Hypertension	50.44%	43.50%	0.140
Diabetes mellitus	22.81%	14.35%	0.016
Congestive heart failure	19.74%	17.94%	0.644
Cardiac arrhythmias	42.11%	43.50%	0.747
Valvular heart disease	6.58%	2.69%	0.051
Pulmonary circulation disorder	10.96%	8.52%	0.384
Renal failure	12.28%	10.31%	0.522
Liver disease	8.33%	8.97%	0.811
Coagulopathy	12.28%	13.45%	0.708
Obesity	7.46%	11.21%	0.164
Metastatic cancer	67.98%	60.54%	0.093

Measures of clinical acuity were also similar between groups. Shock was observed more often in the early-drainage group than in the delayed-drainage group (17.5% vs 11.7%; p = 0.07), whereas respiratory failure occurred at comparable frequencies (22.4% vs 24.2%; p = 0.64). The distribution of cancer subtypes is presented in Fig. 1. Respiratory malignancies comprised the largest subgroup (28.3%), followed by breast cancer (8.2%). The full cancer subtype distribution is provided in Additional file 1.

In-hospital outcomes are summarized in Table 2. Delayed drainage was associated with higher unadjusted in-hospital mortality than early drainage (14.80% vs 8.77%; p = 0.052). Delayed drainage was also associated with a longer mean length of stay (10.12 vs 7.04 days; p < 0.01) and higher mean inflation-adjusted total hospital charges (174178 vs 113922.9; p < 0.01).

Table 2
In-hospital outcomes by drainage timing Values are survey-weighted percentages or means (SE). Hospital charges were inflation-adjusted.

Outcome	Early drainage (day 0)	Delayed drainage (day ≥ 1)	p value
In-hospital mortality	8.77%	14.80%	0.052
Length of stay, mean (SE)	7.04 (0.41)	10.12 (0.74)	< 0.01
Inflation-adjusted charges, mean (SE)	113922.9 (10415)	174178 (20213)	< 0.01

Table 3 and Fig. 2 show the adjusted analysis for in-hospital mortality. Delayed pericardiocentesis remained independently associated with increased odds of in-hospital death (aOR 2.21; 95% CI 1.11–4.41; p = 0.025). Coagulopathy (aOR 3.70; 95% CI 1.62–8.46; p = 0.002), cardiac arrhythmias (aOR 2.03; 95% CI 1.01–4.09; p = 0.048), and African American race compared with White race (aOR 4.13; 95% CI 1.93–8.86; p < 0.001) were also associated with higher in-hospital mortality. Age, sex, hypertension, congestive heart failure, valvular heart disease, pulmonary circulation disorders, renal failure, liver disease, and obesity were not significantly associated with mortality in the final model.

Table 3

Adjusted odds of in-hospital mortality Multivariable survey-weighted logistic regression with in-hospital mortality as the dependent variable. Reference groups were day 0 drainage, male sex, and White race.

Variable	Adjusted OR	95% CI	p value
Delayed drainage (day ≥ 1 vs day 0)	2.21	1.11–4.41	0.025
Age	1.01	0.98–1.04	0.635
Female sex	1.05	0.56–1.95	0.889
African American race (vs White)	4.13	1.93–8.86	< 0.001
Hispanic race (vs White)	1.50	0.59–3.78	0.390
Other race (vs White)	1.11	0.27–4.60	0.886
Hypertension	0.46	0.21–1.02	0.056
Diabetes mellitus	2.34	0.98–5.59	0.056
Congestive heart failure	1.12	0.52–2.43	0.771
Cardiac arrhythmias	2.03	1.01–4.09	0.048
Valvular heart disease	0.66	0.16–2.65	0.558
Pulmonary circulation disorder	0.49	0.14–1.72	0.264
Renal failure	0.83	0.35–1.98	0.676
Liver disease	2.21	0.86–5.71	0.100
Coagulopathy	3.70	1.62–8.46	0.002
Obesity	0.54	0.14–2.15	0.385

Discussion

In this nationally representative analysis of cancer-related hospitalizations complicated by cardiac tamponade, delayed pericardiocentesis was associated with worse in-hospital outcomes. Compared with drainage performed on hospital day 0, delayed drainage was associated with higher in-hospital mortality, longer hospitalization, and greater inflation-adjusted hospital charges. After multivariable adjustment, delayed drainage remained independently associated with more than twofold higher odds of in-hospital death. These findings support the clinical principle that timely decompression is central to the management of tamponade in cardio-oncology practice (9, 10).

Our results are clinically plausible and align with existing guidance that prioritizes urgent drainage while allowing only brief deferral in carefully selected, closely monitored patients (10). In real-world oncology populations, however, same-day drainage may not always be achieved because of delayed recognition,

the need for confirmatory imaging, thrombocytopenia or coagulopathy, anticoagulation reversal, limited procedural availability, or competing oncologic decision-making (11–16). The observation that only about half of hospitalizations underwent drainage on day 0 suggests a potentially modifiable systems-level gap in care delivery. Similar improvements in other time-sensitive cardiovascular emergencies have been achieved through standardized workflows and quality-improvement initiatives (18–20).

The cancer subtype distribution in our cohort also supports the face validity of the study population, with respiratory malignancies and breast cancer representing the most common groups, consistent with prior reports of malignant pericardial disease (1, 4–8). In the adjusted model, coagulopathy and cardiac arrhythmias were also associated with higher in-hospital mortality, which is clinically plausible in a population characterized by hemodynamic instability, advanced malignancy, and procedure-related bleeding risk. The higher adjusted mortality observed among African American patients warrants further investigation to clarify the potential roles of illness severity, access to timely specialty care, procedural timing, hospital-level factors, and broader structural inequities (17).

This study has several limitations. First, the NIS is an administrative database and lacks detailed clinical information such as vital signs, echocardiographic findings, tamponade severity, laboratory values, cancer stage, treatment status, and goals of care. Second, identification of tamponade, cancer subtype, and pericardial drainage relied on ICD-10 coding and may be subject to misclassification. Third, the timing variable is derived from days from admission to procedure and may be affected by coding practices. Fourth, the database does not provide procedural granularity such as imaging guidance, drainage duration, complications, or recurrence. Finally, because this is an observational study of hospitalizations rather than unique patients, residual confounding is likely and longitudinal outcomes cannot be assessed. Despite these limitations, the large nationally representative sample provides useful real-world insight into a high-acuity cardio-oncology emergency.

Conclusions

Among cancer-related hospitalizations complicated by cardiac tamponade that underwent pericardiocentesis or pericardial drainage, delayed drainage on hospital day 1 or later was independently associated with higher in-hospital mortality, longer hospitalization, and greater hospital charges. These findings identify a potentially actionable opportunity to improve care for a high-risk population by strengthening inpatient workflows that support earlier recognition and timely drainage. Prospective studies are needed to identify specific causes of delay and evaluate targeted quality-improvement strategies.

Abbreviations

aOR
adjusted odds ratio
CI

confidence interval
HCUP
Healthcare Cost and Utilization Project
HIPAA
Health Insurance Portability and Accountability Act
ICD-10-CM
International Classification of Diseases,Tenth Revision,Clinical Modification
ICD-10-PCS
International Classification of Diseases,Tenth Revision,Procedure Coding System
LOS
length of stay
NIS
National Inpatient Sample.

Declarations

Ethics approval and consent to participate

This study used de-identified discharge-level data from the HCUP National Inpatient Sample. Institutional review board review and informed consent were not required for this analysis of de-identified data.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

CP and NS conceived the study. CP, NS, and PY designed the analysis. CP and NS drafted the initial manuscript. CP, NS, PY, NL, DS, TS, TY, and NK contributed to interpretation of data, critically revised the manuscript, and approved the final manuscript.

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During the preparation of this manuscript, the authors used OpenAI for language editing and formatting assistance. The authors reviewed and edited the output as needed and take full responsibility for the content of the manuscript.

Authors' information

Not applicable.

Data Availability

The data that support the findings of this study are available from the HCUP National Inpatient Sample, subject to HCUP purchase and data use agreement restrictions. These source data are therefore not publicly available. Summary source data underlying the tables and figures are provided in Additional file 1. Analytic code is available from the corresponding author on reasonable request.

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Figures

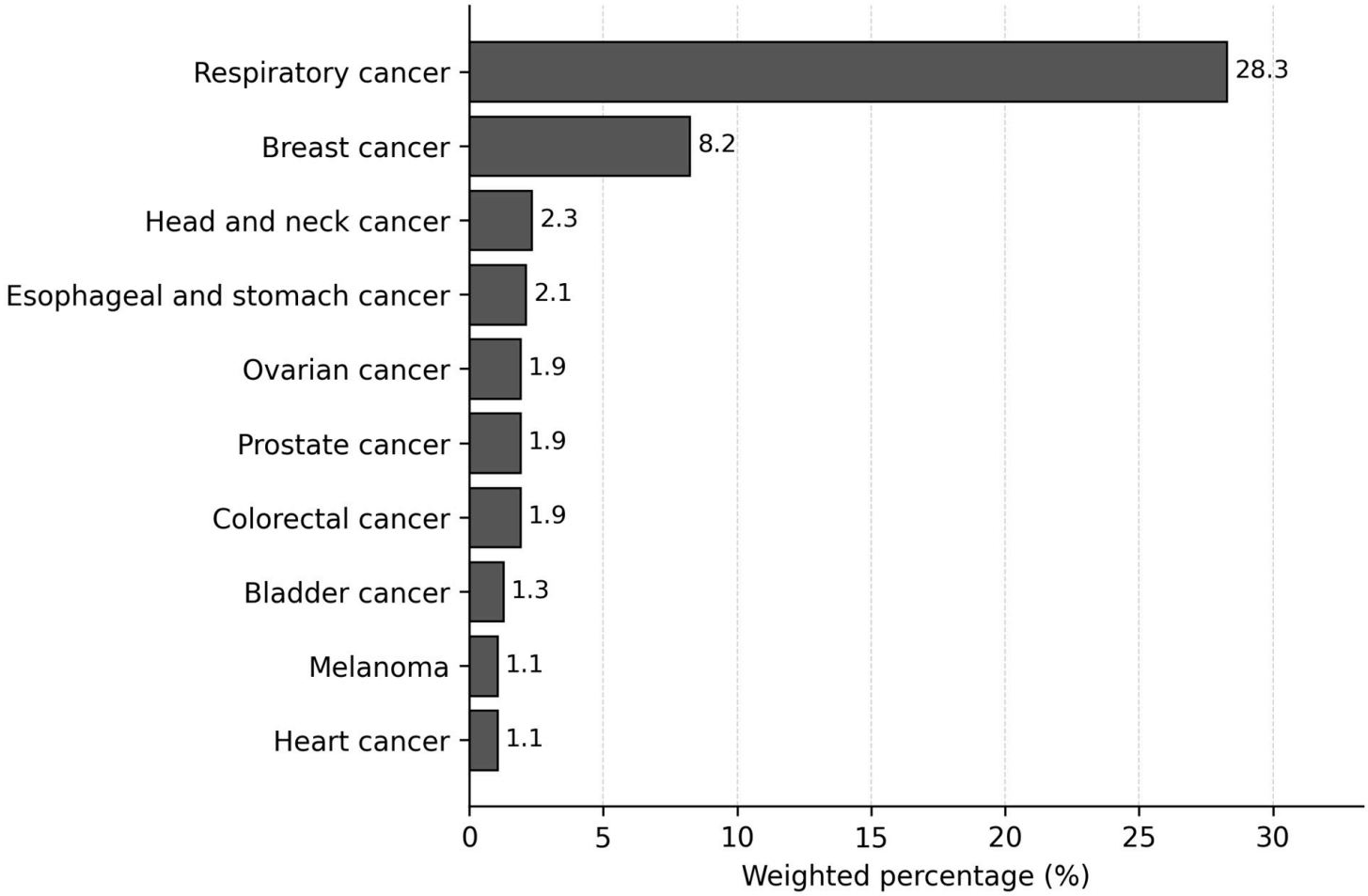

Figure 1

Cancer type distribution among included hospitalizations

Horizontal bar chart showing the 10 most common cancer categories among cancer-related hospitalizations with cardiac tamponade that underwent pericardiocentesis or pericardial drainage. Values are survey-weighted percentages; the full cancer subtype distribution is provided in Additional file 1.

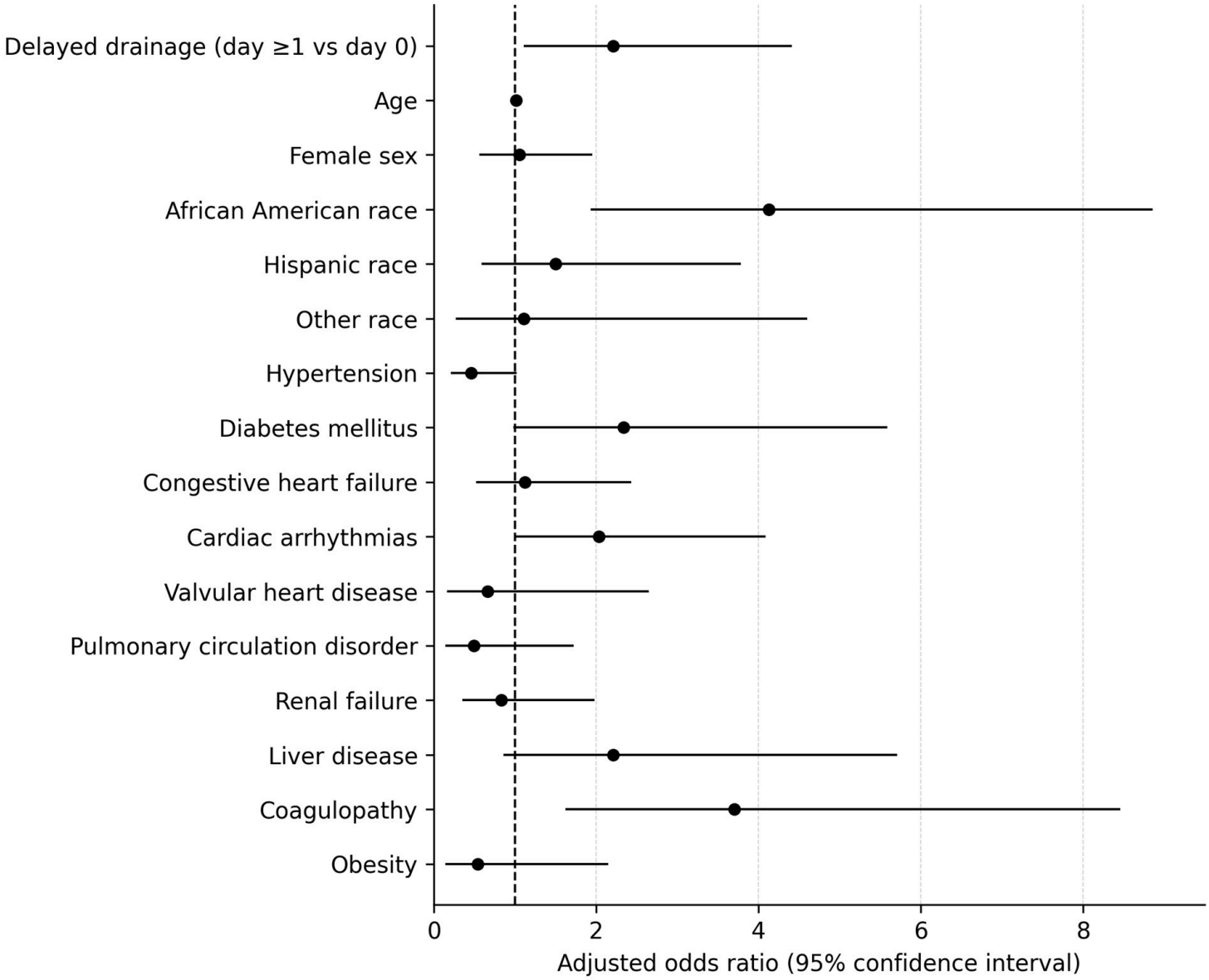

Figure 2

Adjusted odds of in-hospital mortality

Forest plot of adjusted odds ratios with 95% confidence intervals from the multivariable survey-weighted logistic regression model. The dashed vertical line indicates an odds ratio of 1.0.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CardioOncologyAdditionalFile1.xlsx