A Nationwide Comparison of Reperfusion Strategies in High-Risk Pulmonary Embolism Patients Receiving ECMO

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Background

- High-risk pulmonary embolism (PE), defined by the presence of PE with cardiac arrest, sustained hypotension, or shock, is associated with a 30-day mortality rate exceeding 30% (1,2)
- Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) can serve as effective salvage therapy in high-risk PE patients who experience circulatory collapse or cardiac arrest (1,3-8)
- VA-ECMO can be used as a destination therapy or in combination with surgical pulmonary embolectomy (SPE), catheter-directed interventions (CDI) [including catheter-directed thrombolysis (CDT) and catheter-directed embolectomy (CDE)], and systemic thrombolysis (ST)
- While VA ECMO can serve as a vital bridge to definitive reperfusion, comparative analysis assessing the utility of various reperfusion methods in this patient population is limited
- The primary aim of this study was to compare how reperfusion with SPE, CDI, and ST impacts in-hospital outcomes among high-risk PE patients cannulated for VA-ECMO

Methods

Data Source and Population

- We queried the **National Inpatient Sample (NIS) from 2016-2021** for adult patients (Age ≥ 18) with acute high-risk PE defined by the presence of PE with cardiac arrest, non-septic shock, hypotension, or vasopressor use, consistent with the 2019 European Society of Cardiology guidelines (3)
- Study design with inclusion and exclusion criteria is illustrated in **Figure 1**

Outcome Measures

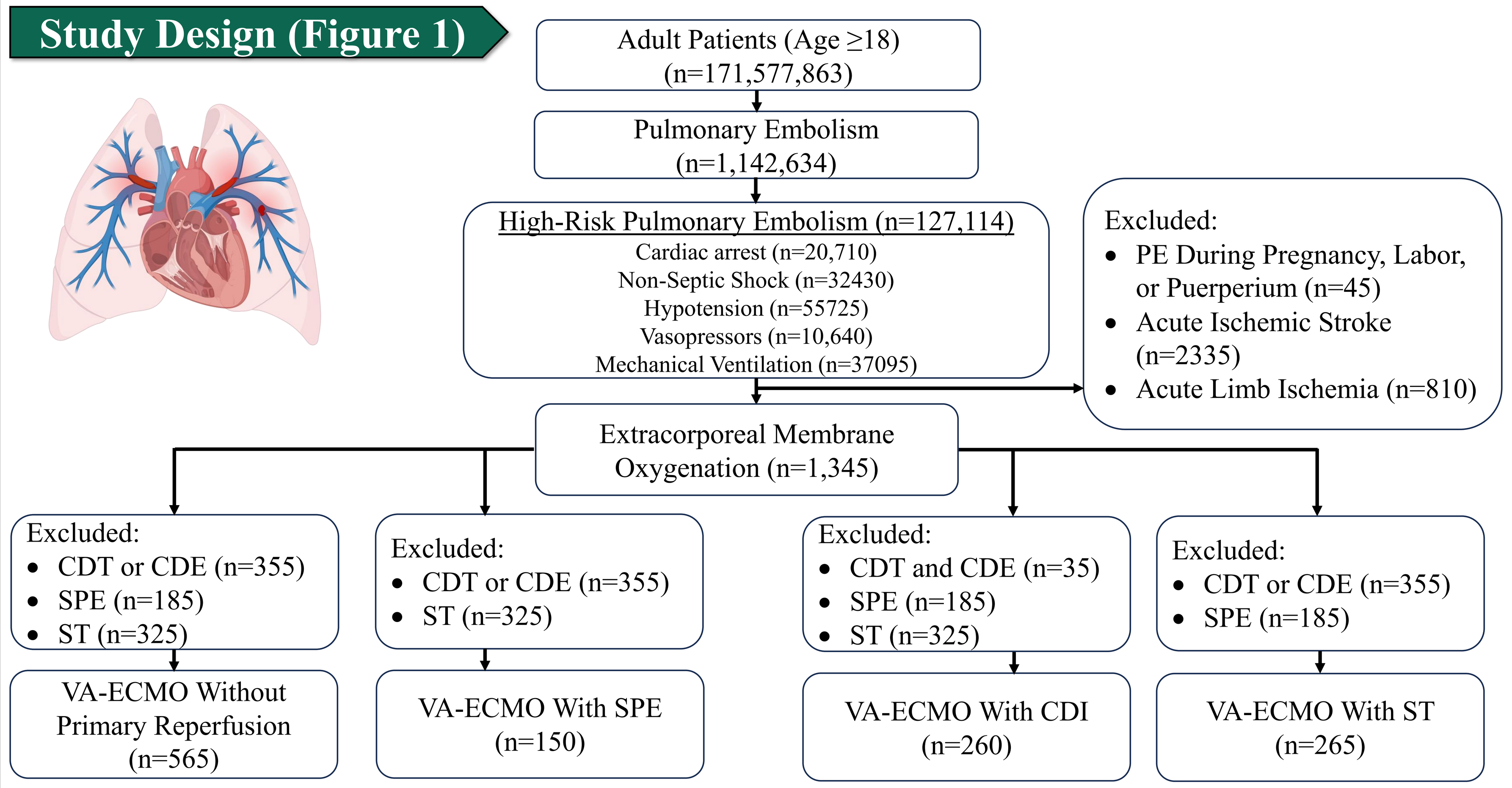
- **Primary outcomes:**
  - ➢ In-hospital mortality, hospital length of stay (HLOS), and hospital disposition
- **Secondary outcomes:**
  - ➢ Intracranial hemorrhage, non-intracranial hemorrhage†, and In-hospital complications

Non-intracranial hemorrhage† = Gastrointestinal bleeding, gynecological bleeding, hemarthrosis, hematuria, hemopericardium, hemoperitoneum, hemothorax, intraocular bleeding, respiratory bleeding, and postprocedural bleeding

Statistical Analysis

- **Frequencies** compared using chi-squared or Fisher's exact tests (when n < 10) followed by post hoc analysis using a z-test of two proportions with Bonferroni correction
- **Medians** compared using Kruskal-Wallis tests with pairwise comparison using Dunn's procedure
- **Multivariable logistic and linear regression** were used to assess the association between each intervention and hospital complications, in-hospital mortality, disposition, and HLOS
- **Adjusted regression was performed controlling for confounders**: Age, gender, race, hospital bed size, hospital location, primary payer, Elixhauser comorbidities, cardiac arrest, non-septic shock, vasopressor use, hypotension, and mechanical ventilation
- **Statistical analysis conducted using IBM SPSS, Version 28 (Armonk, New York)**

Study Design (Figure 1)



Results

Demographics

Table 1. Patient demographics according to treatment modality. The values are reported as the number of patients and percent or as the median and interquartile range (IQR).

	VA-ECMO Alone (N =565)	VA-ECMO With SPE (N =150)	VA-ECMO With CDI (N =260)	VA-ECMO With ST (N =265)	*P-value*
Median age (years)	**53.0 (41.00 - 63.00)[A]**	59.0 (46.00 - 69.00)[B]	58.0 (48.50 - 68.75)[B]	59.0 (46.00 - 67.00)[B]	**<0.001**
Gender					
Male	335 (59.3%)	85 (56.7%)	130 (50.0%)	120 (45.3%)	0.411
Female	230 (40.7%)	65 (43.3%)	130 (50.0%)	145 (54.7%)	0.411
Race					
White	365 (64.6%)	105 (70.0%)	165 (63.5%)	170 (64.2%)	0.766
Black	125 (22.1%)	35 (23.3%)	85 (32.7%)	80 (30.2%)	0.492
Hispanic	50 (4.8%)	10 (6.7%)	10 (3.8%)	10 (3.8%)	0.526
Asian/Pacific Islander	5 (4.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.236
Other	20 (3.5%)	0 (0.0%)	0 (0.0%)	5 (1.9%)	0.496
Hospital Location					
Urban Teaching	550 (97.3%)	145 (96.7%)	255 (98.1%)	245 (92.5%)	0.221
Urban Non-teaching	15 (2.7%)	5 (3.3%)	5 (1.9%)	15 (5.7%)	0.472
Rural	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (1.9%)	0.245
Hospital Bed Size					
Large	490 (86.7%)[A]	100 (66.7%)[B]	210 (80.8%)[A,C]	190 (71.7%)[B,C]	**0.029**
Medium	60 (10.6%)	35 (23.3%)	40 (15.4%)	60 (22.6%)	0.158
Small	15 (2.7%)	15 (10.0%)	10 (3.8%)	15 (5.7%)	0.132
Primary Payer					
Medicare	160 (28.3%)	60 (40.0%)	95 (36.5%)	85 (32.1%)	0.498
Medicaid	75 (13.3%)	20 (13.3%)	20 (7.7%)	40 (15.1%)	0.437
Private insurance	275 (48.7%)	70 (46.7%)	125 (48.1%)	115 (43.4%)	0.884

Utilization of Reperfusion Strategies Over Time

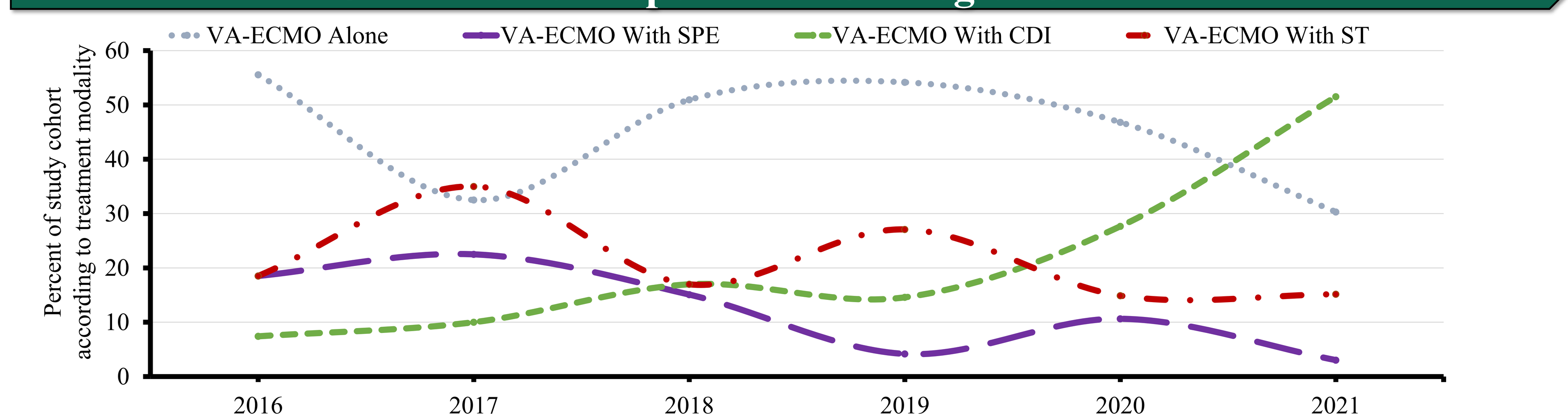


Figure 2. Represents the percent of the study cohort receiving each treatment modality over time.

Predictors of ECMO Use

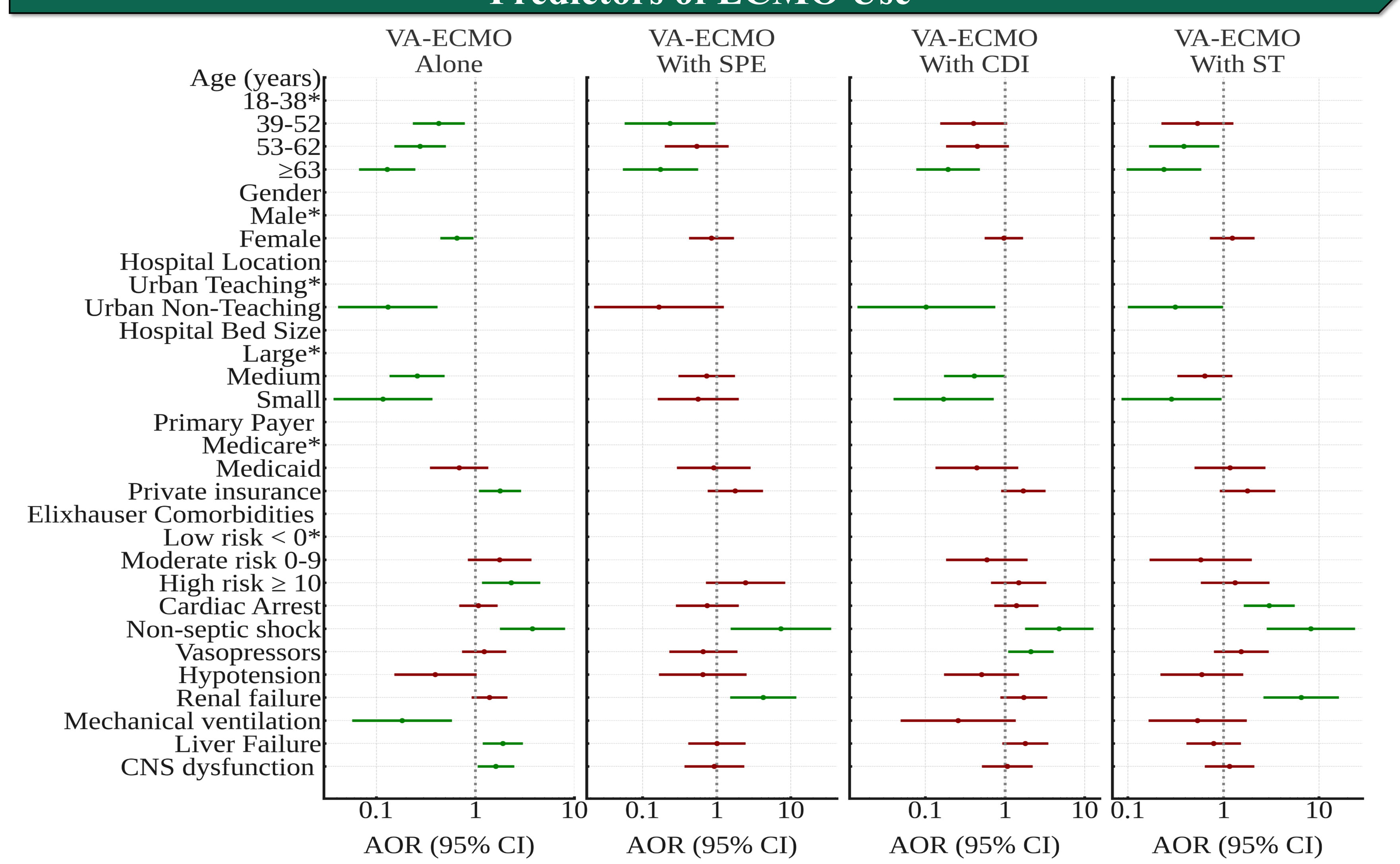
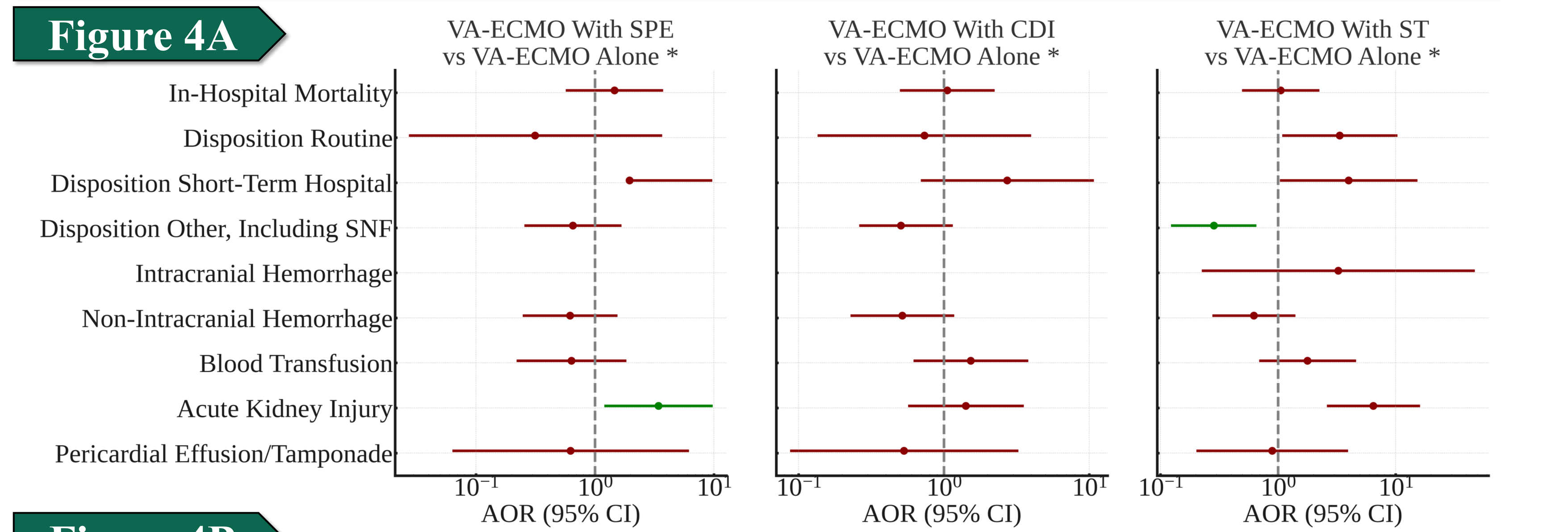
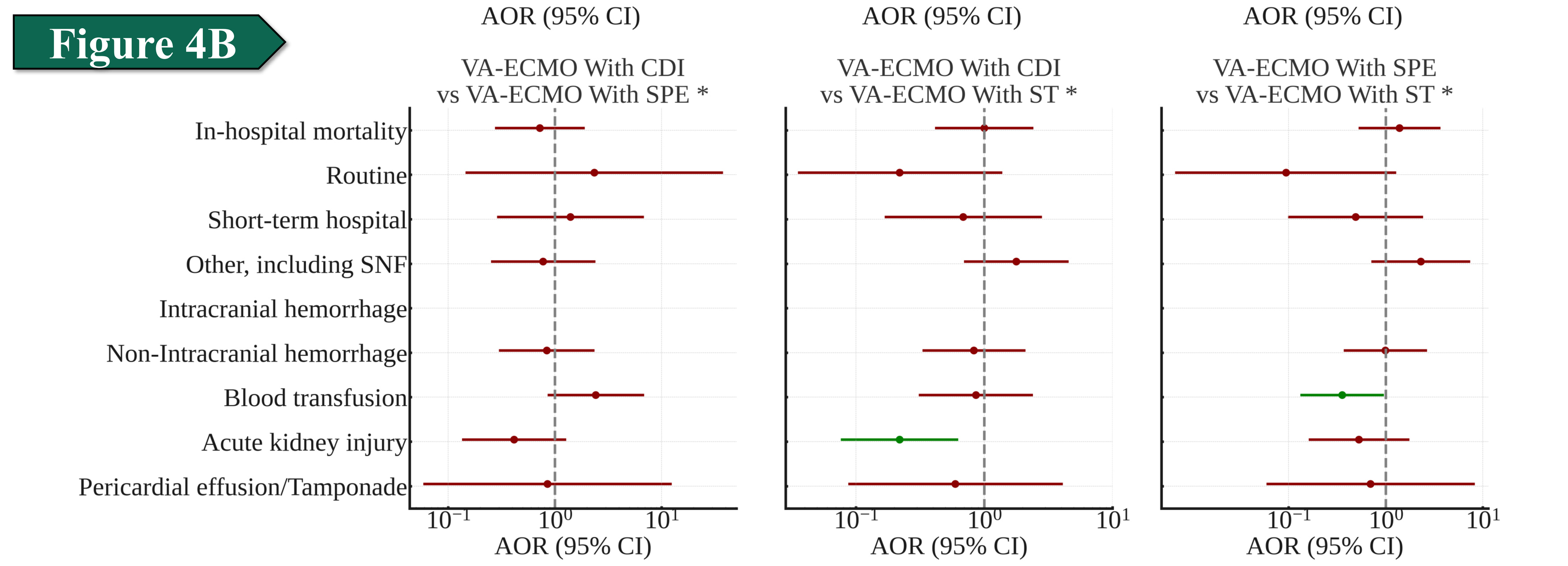


Figure 3. Predictors of ECMO use either alone or with primary reperfusion. Note: * = Reference.

Multivariable Regression Results





Figures 4A and 4B. Multivariable regression results predicting primary and secondary outcomes according to treatment modality. Note: * = Reference Category.

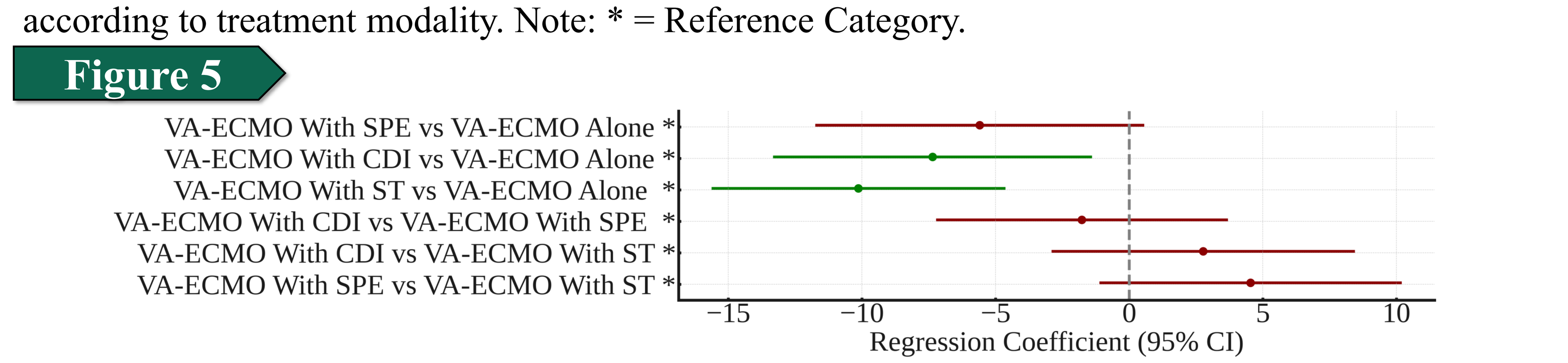


Figure 5. Multivariable regression results predicting hospital length of stay according to treatment modality. Note: * = Reference Category.

Conclusion

- The increased use of VA-ECMO with CDI during the study matches Medicare data, which shows a tenfold rise in CDI use for acute PE from 2004 to 2016 (9,10)
- Our findings examining predictors of VA-ECMO use support data that VA-ECMO is more commonly used at large academic centers for younger privately insured patients who are likely to recover (11,12)
- Use of VA-ECMO with CDI was associated with less acute kidney injury (AKI) versus VA-ECMO with ST, with no associated increase in bleeding risk or transfusion requirement
- Patients managed with VA-ECMO and CDI may achieve more rapid hemodynamic stabilization, resulting in less end-organ injury, such as AKI, without an increase in major bleeding
- The use of CDI and ST was associated with a shorter HLOS compared to patients treated with VA-ECMO alone, which may also suggest earlier hemodynamic stabilization (13)
- Overall, our findings indicate that CDI may be a preferred method of definitive reperfusion for high-risk PE patients on VA-ECMO and highlight a need for randomized controlled trials to verify these results

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