CHEST

# The Association Between Indwelling Arterial Catheters and Mortality in Hemodynamically Stable Patients With Respiratory Failure

## A Propensity Score Analysis

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**BACKGROUND:** Indwelling arterial catheters (IACs) are used extensively in the ICU for hemodynamic monitoring and for blood gas analysis. IAC use also poses potentially serious risks, including bloodstream infections and vascular complications. The purpose of this study was to assess whether IAC use was associated with mortality in patients who are mechanically ventilated and do not require vasopressor support.

**METHODS:** This study used the Multiparameter Intelligent Monitoring in Intensive Care II database, consisting of > 24,000 patients admitted to the Beth Israel Deaconess Medical Center ICU between 2001 and 2008. Patients requiring mechanical ventilation who did not require vasopressors or have a diagnosis of sepsis were identified, and the primary outcome was 28-day mortality. A model based on patient demographics, comorbidities, vital signs, and laboratory results was developed to estimate the propensity for IAC placement. Patients were then propensity matched, and McNemar test was used to evaluate the association of IAC with 28-day mortality.

**RESULTS:** We identified 1,776 patients who were mechanically ventilated who met inclusion criteria. There were no differences in the covariates included in the final propensity model between the IAC and non-IAC propensity-matched groups. For the matched cohort, there was no difference in 28-day mortality between the IAC group and the non-IAC group (14.7% vs 15.2%; OR, 0.96; 95% CI, 0.62-1.47).

**CONCLUSIONS:** In hemodynamically stable patients who are mechanically ventilated, the presence of an IAC is not associated with a difference in 28-day mortality. Validation in other datasets, as well as further analyses in other subgroups, is warranted.

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**ABBREVIATIONS:** HR = hazard ratio; IAC = indwelling arterial catheter; IQR = interquartile range; LOS = length of stay; MIMIC-II = Multiparameter Intelligent Monitoring in Intensive Care-II; RCT = randomized controlled trial

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Indwelling arterial catheters (IACs) are used in the ICU setting for continuous hemodynamic monitoring and for arterial blood sampling for blood gas analysis. IAC use in the ICU setting is widespread, occurring in approximately 30% of all patients in the ICU, with relatively stable IAC use over time.[1-3]

Despite widespread IAC use, there are rare but potentially serious complications that may arise. IAC-associated bloodstream infections have been reported at a rate that, although not to the level of central venous catheters, is significantly higher than peripheral venous access. A systematic review of the risk of bloodstream infections associated with intravascular catheters reports a pooled point estimate of 1.6 per 1,000 device days (95% CI, 1.2-2.3) for IAC compared with 0.5 (95% CI, 0.2-0.7) for peripheral venous access and 2.7 (95% CI, 2.6-2.9) for central venous catheters.[4] Additionally, vascular complications associated with IAC use are more common than previously believed, including thrombosis, ischemia, hematoma, bleeding, and pseudoaneurysm.[5] The presence of an IAC may promote increased frequency of blood draws and laboratory testing, including arterial blood gas sampling.[6,7]

In the context of increased IAC-associated use and complications, there are scant outcomes data to support their widespread use. The purpose of this study was to examine the association between IAC use and outcomes in a large cohort of hemodynamically stable intensive care patients with respiratory failure undergoing mechanical ventilation.

## Materials and Methods

### *Study Population*

We conducted a longitudinal, single-center, retrospective cohort study of patients from the Multiparameter Intelligent Monitoring of Intensive Care (MIMIC-II) database, which includes patients admitted between 2001 and 2008. The database contains data from 24,581 patients in ICUs and includes physiologic information from bedside monitors and hospital information systems in the adult ICUs at Beth Israel Deaconess Medical Center, a tertiary care university academic medical center located in Boston, Massachusetts.[8] The data in MIMIC-II has been previously deidentified, and the institutional review boards of the Massachusetts Institute of Technology (No. 0403000206) and Beth Israel Deaconess Medical Center (2001-P-001699/14) both approved the use of the database for research.

The MIMIC-II database was searched to identify adult patients requiring mechanical ventilation within the first 24 h of medical or surgical ICU admission and lasting for at least 24 h. The presence of an IAC was defined as placement of an invasive arterial catheter at any point in time after initiation of mechanical ventilation. Patients were excluded if they had a diagnosis of sepsis based on the Angus criteria[9] or required vasopressors while in the ICU or if IAC placement was performed prior to endotracheal intubation and initiation of mechanical ventilation (including pre-ICU admission IAC placement). As the majority of patients in the cardiac surgery recovery unit had an IAC placed prior to ICU arrival, all patients from the cardiac surgery ICU were also excluded from this analysis. Additionally, to ensure the independence of data, only the first ICU admission was included in patients who had multiple ICU admissions.

Coincident diseases were obtained based on *International Classification of Diseases, Ninth Revision, Clinical Modification*. The Sequential Organ Failure Assessment (SOFA) score was obtained at the time of ICU admission, and laboratory values immediately preceding onset of mechanical ventilation were used.

### *Outcome Measures*

The primary outcome was 28-day mortality. Secondary outcomes included ICU and hospital length of stay (LOS), duration of mechanical ventilation, and mean number of arterial and venous blood gas measurements performed per day while admitted to the ICU.

### *Statistical Analysis*

A propensity score model was created to match baseline patient characteristics. Twenty-nine pre-IAC placement features, including patient demographics, comorbidities, vital signs, and preintervention laboratory results, were selected from 53 available candidate variables (those without significant missing data) to estimate the propensity for IAC insertion using a genetic algorithm (e-Appendix 1).[10] Patients with or without IAC placement were then matched based on the estimated propensity scores using one-to-one matching without replacement with a caliper of 0.01. To ensure the robustness of the propensity score model and to avoid over-fitting, the goodness-of-fit of the prediction model was evaluated based on the average area under the receiver operating characteristic curve using 10-fold cross-validation, and the predictive model was also evaluated with the Hosmer-Lemeshow test.

The success of the propensity score model was evaluated by assessment of the differences in baseline covariates between IAC and non-IAC groups. As continuous variables were not normally distributed, median values and interquartile range (IQR) were used to summarize distributions. The Fisher exact test and Wilcoxon rank-sum test were applied to statistically assess the differences in categorical and continuous variables between the unmatched IAC and non-IAC groups. Measures of association for baseline covariates in the propensity-matched cohorts were performed using either McNemar test for categorical variables or Wilcoxon signed rank test for continuous variables. The distributions of the propensity score before and after matching were also compared to further assess the degree of balance.

In univariate analyses, a McNemar test was performed for binary outcomes and paired *t* tests for continuous outcomes. As mortality is a competing risk for ICU LOS, total LOS, and duration of mechanical ventilation, we used the cumulative incidence function to estimate the probability of the secondary outcome over 28 days while allowing for the possibility of alternative outcomes (eg, death) to occur.[11]

### *Sensitivity Analyses*

Sensitivity analyses were performed to evaluate the effects of varying both the inclusion criteria of time to mechanical ventilation (to include all patients undergoing endotracheal intubation at any point during their ICU course) and the caliper level for propensity matching on the association between IAC placement and 28-day mortality. Ten different caliper levels between 0.01 and 0.1 at 0.01 increments were used to match the positive and negative controls. We also performed a sensitivity analysis using propensity score weights to create an alternative propensity score model for IAC placement. This method optimizes postweighting balance of covariates between groups, and a weighted regression model including any imbalanced covariates between the matched groups was estimated for 28-day mortality (e-Appendix 1).