**Incidence and Outcomes of Acute Circulatory Support Prior to Heart Transplantation**

**Background**: Proposed changes to the UNOS heart allocation protocol could prioritize patients with acute circulatory support, including extracorporeal membrane oxygenation (ECMO), percutaneous ventricular assist devices (PVAD), and intra-aortic balloon pumps (IABP). We sought to evaluate contemporary trends in the incidence and outcomes of patients who required acute circulatory support during the hospitalization prior to heart transplantation.

**Methods**: From the Nationwide Inpatient Sample (NIS) from 1998 to 2011, we identified 5,381 patients who underwent orthotopic heart transplant (OHT) and determined whether the patient underwent pre-transplant ECMO, PVAD, or IABP. We calculated baseline characteristics and compared patients who underwent acute circulatory support with patients who did not require acute circulatory support prior to heart transplantation.

**Results**: Of patients who underwent heart transplantation, 337 (6.3%) patients required acute circulatory support prior to transplant. During the study time period, the use of acute circulatory support has increased (p = 0.003 for trend) from 17 cases per year from 2008-2010 to 33 cases per year from 2009 - 2011. In this population, 253 (75.1%) patients were supported by IABP, 102 (30.3%) were supported by ECMO, and 4 (1.2%) were supported by PVAD. Patients who required circulatory support had increased length of stay (69.2 vs. 40.9 days, p < 0.001) and increased in-hospital mortality (10.1% vs. 6.3%, p = 0.009). Patients who had acute circulatory support had less comorbid diabetes, hypertension, or pre-existing renal dysfunction, however during the hospitalization had increased acute renal failure, liver failure, respiratory failure, cardiac complications, bleeding complications, and surgical complications requiring reoperation.

**Conclusions**: In this cohort, we found an increasing proportion of patients receiving acute circulatory support prior to heart transplantation. These patients exhibited significantly increased inpatient mortality, longer lengths of stays, and increased frequency of complications compared to those without acute circulatory support. Changes to the UNOS heart allocation protocol should take both this increased mortality and mortality and the trend of increased support use over time into consideration.

**Key Words -** Mechanical Circulatory Support, Orthotopic Heart Transplant, UNOS allocation,

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|  | **Acute Circulatory Support** | **None** | **Total** |  | |
| **n = 337** | **n = 5022** | **n = 5381** | p-value | |
| Age, mean ± SD | 47.2 ± 17.5 | 46.5 ± 18.7 | 48.1 ± 16.8 | 0.47 | |
| Sex, n (%) | | | |  | |
| Male | 257 (76.3) | 3660 (72.6) | 3917 (72.8) | 0.2 | |
| Female | 80 (23.7) | 1383 (27.4) | 1463 (27.2) |  | |
| Race, n (%) | | | |  | |
| White | 199 (61.6) | 2851 (69.9) | 3050 (56.7) | 0.006 | |
| Black | 47 (14.6) | 633 (15.5) | 680 (12.6) |  | |
| Hispanic | 34 (10.5) | 386 (9.5) | 420 (7.8) |  | |
| Asian/Pacific Islander | 12 (3.7) | 121 (3.0) | 133 (2.5) |  | |
| Native American | 0 (0.0) | 16 (0.4) | 16 (0.3) |  | |
| Other or unknown | 45 (13.4) | 1037 (20.6) | 1082 (18.2) |  | |
| Median household income, n (%) | | | |  | |
| $1-24,999 | 53 (14.8) | 797 (15.9) | 850 (15.8) | 0.8 | |
| $25,000-34,999 | 84 (23.4) | 1177 (23.4) | 1261 (23.4) |  | |
| $35,000-44,999 | 84 (23.4) | 1335 (26.6) | 1419 (26.4) |  | |
| $45,000 or more | 110 (30.6) | 1601 (31.9) | 1711 (31.8) |  | |
| Unknown | 6 (1.7) | 134 (2.7) | 140 (2.6) |  | |
| Comorbidities | | | |  | |
| Diabetes | 50 (14.8) | 999 (19.9) | 1049 (19.5) | 0.03 | |
| Ischemic Heart Disease | 156 (46.3) | 2248 (44.8) | 2404 (44.8) | 0.62 | |
| Hypertension | 71 (21.1) | 1447 (28.8) | 1518 (28.2) | 0.003 | |
| Preexisting Renal Dysfunction | 75 (22.2) | 1641 (32.7) | 1716 (31.9) | < 0.001 | |
| Peripheral Vascular Disease | 5 (1.5) | 83 (1.7) | 88 (1.6) | 0.99 | |
| History of smoking | 14 (4.2) | 297 (5.9) | 311 (5.8) | 0.22 | |
| BMI ≥ 30 kg/m2 | 7 (2.1) | 130 (2.6) | 137 (2.5) | 0.69 | |
| Location of Hospital, n (%) | | | |  | |
| Urban | 337 (100.0) | 4971 (99.8) | 5308 (99.8) | 0.99 | |
| Rural | 0 (0.0) | 8 (0.2) | 8 (0.2) |  | |
| Bedsize of Hospital, n (%) | | | |  | |
| Small | 6 (1.7) | 120 (2.4) | 126 (2.4) | 0.08 | |
| Medium | 59 (17.5) | 737 (14.9) | 796 (15.0) |  | |
| Large | 272 (80.7) | 4122 (83.2) | 4394 (82.6) |  | |
| Teaching Hospital, n (%) | | | |  | |
| Teaching | 323 (95.8) | 4547 (91.7) | 4870 (91.6) | 0.006 | |
| Non - Teaching | 14 (4.2) | 432 (8.7) | 446 (8.4) | |  |

Table 1: Baseline characteristics of patients who underwent cardiac transplant from 1998 to 2011, divided by use of acute mechanical support prior to transplantation

Table 2: Mortality, length of stay, complications in patients who underwent cardiac transplant from 1998 to 2011, divided by use of acute mechanical support prior to transplantation

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|  | **Acute Circulatory Support** | **None** |  |
| **n = 337** | **n = 5022** | **p-value** |
| Length of stay, mean ± SD | 69.2 ± 50.6 | 40.9 ± 49.2 | < 0.001 |
| Mortality, n (%) | 34 (10.1) | 316 (6.3) | 0.009 |
| Post Transplant Circulatory Support | 2 (0.6) | 64 (1.3) | 0.4 |
| Acute Renal Failure | 168 (49.9) | 1616 (32.2) | < 0.001 |
| Acute Liver Failure | 31 (9.2) | 128 (2.5) | < 0.001 |
| Acute Respiratory Failure | 97 (28.8) | 474 (9.4) | < 0.001 |
| Cardiac Complications | 56 (16.6) | 620 (12.3) | 0.028 |
| Sepsis | 33 (9.8) | 201 (9.2) | < 0.001 |
| Stroke | 10 (3.0) | 98 (2.0) | 0.278 |
| Surgical Complication Requiring Reoperation | 90 (26.7) | 690 (13.7) | < 0.001 |
| Bleeding Complication | 117 (34.7) | 935 (18.6) | < 0.001 |

Supplement A: ICD-9 codes of comorbid conditions

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| **Comorbidty** | **ICD-9 codes** |
| Diabetes Mellitus | 250.00-250.93, 249.00-249.91 |
| Ischemic Heart Disease | 410.0-410.9, 411.0-411.8, 412, 413.0-413.9, 414.0-414.9, V45.8, V45.82 |
| Hypertension | 401.0-401.9, 402.0, 402.00-402.91, 403.0, 403.00-403.91, 404.0 404.00-404.93, 405.0, 405.01-405.91, 437.2 |
| Pre-existing renal dysfunction | 585.3, 585.4, 585.5, 585.6, 585.9, V42.0, V45.1, V45.11, V45.12, V56.0, V56.1, V56.2, V56.3, V56.31, V56.32, V56.8 |
| Peripheral vascular disease | 440.0-440.9, 443.1, 443.8,443.81, 443.82, 443.89, 443.9, 447.1, V43.4 |
| History of smoking | 305.1, V15.82 |
| BMI > 30 kg/m2 | 278.0, 278.01, 278.02 |

Supplement B: ICD-9 codes of complications

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| **Complication** | **ICD-9 codes** |
| Post Transplant Circulatory Support1 | 37.61, 37.68, 39.61 |
| Acute Renal Failure | 584.5, 584.6, 584.7, 584.8, 584.9 |
| Acute Liver Failure | 570 |
| Acute Respiratory Failure | 518.81 |
| Cardiac Complications | 997.1, 429.4, 432.0, 432.3, 426.0 |
| Sepsis | 995.91, 995.92 |
| Stroke | 433.0-433.9, 434.0-434.9 |
| Surgical Complication Requiring Reoperation | 340.3, 341, 347.9, 380.3 |
| Bleeding Complication | 530.21 ,456.0 ,530.7 ,530.82 ,578.0 ,578.1 ,578.9 ,456.20 ,531.00 ,531.01 ,531.20 ,531.21 ,531.40 ,531.41 ,531.60 ,531.61 ,532.00 ,532.01 ,532.20 ,532.21 ,532.40 ,532.41 ,532.60 ,532.61 ,533.00 ,533.01 ,533.20 ,533.21 ,533.40 ,533.41 ,533.60 ,533.61 ,534.00 ,534.01 ,534.20 ,534.21 ,534.40 ,534.41 ,534.60 ,534.61 ,535.01 ,535.11 ,535.21 ,535.31 ,535.41 ,535.51 ,535.61 ,535.71 ,537.83 ,562.02 ,562.03 ,562.12 ,562.13 ,569.3 ,569.85 ,537.84 ,569.86 |
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1Day of procedure past day of transplant