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Trends in Microbiology Data and Association With Mortality in Infective Endocarditis (2002-2017)

Infective endocarditis (IE) is rising in incidence not only in the US but also worldwide.[1] Very few contemporary studies have evaluated the microbiology and related outcomes in IE. In this study we aim to look at the trends of causative organisms of IE in the US and their association with outcomes. We used the National Inpatient Sample data from year 2002 to 2017.[2] International Classification of Diseases (ICD)-9 and ICD-10 codes were used to identify all hospitalizations with IE and age > 18 years. Patients with no microbiology data were excluded.

A total 421,881 weighted admissions were identified where microbiological data was available. Staphylococcus related IE was the most common (213,287, 50.6%), followed by Streptococcus (105,692, 25.1%), Enterococcus (40,712, 9.7%), and Gram-negative related IE (25,762, 6.1%). Patient with Staphylococcus IE were the youngest (57 years, interquartile range [IQR] [42 to 72]) whereas patients with Enterococcus IE were the oldest (67 years, IQR [53 to 77]) see Table. Co-morbid conditions associated with Staphylococcus IE were end stage renal disease (17.3%) and drug abuse history (21.0%) whereas cancers (6.4%) and cardiac devices (8.9%) were noted in Enterococcus IE. Overall 46,678 (11.1%) patients died during the hospitalization. Mortality was highest in Staphylococcus IE (13.8%) followed by Gram-negative IE (11.0%). Septic shock and long-term intubation (>96 hours) were more common in Staphylococcus (14.0% and 10.3%) and Gram-negative IE (14.4% and 10.5%). Similarly, Staphylococcus and Gram negative IE had longest length of stay (11 days, IQR [7 to 20] and 11 days, IQR [6 to 20]) and highest adjusted cost of stay (USD 23,928, IQR [12.845 to 48,095] and USD24,358, IQR [12,950 to 50,561]) respectively. Patients with Streptococcus and Enterococcus IE were more likely to have valve replacement (14.9% and 13.5%). Multivariate analysis showed Staphylococcus IE had higher mortality and higher odds of sepsis. Streptococcus infections were more likely to undergo valve replacement. Over the years a rise in Enterococcal IE was noted whereas a decline in Staphylococcal and Streptococcal IE was seen.

In this study, Staphylococcal IE had highest mortality, longer length of stay and higher cost. Previous studies showed similar increased in-hospital mortality with Staphylococcal IE both in the operative and nonoperative cohorts.[3] Despite the higher incidence of septic shock, Staphylococcal IE was associated with decreased surgical intervention. The presence of multiorgan failure, sepsis, and deemed futility could be factors associated with decreased surgical intervention.[4] Enterococcus was the third leading cause of IE in our study with a rising incidence. Enterococcal IE was associated with older age and lower in-hospital mortality compared with Staphylococcal IE—an observation that was also noted in a prospective cohort study.[5] The reasons for uptrend in Enterococcal IE needs further study with aging

Table
Baseline characteristics and outcomes of infective endocarditis based on microbial organism. Pearson's chi-square and Kruskal Wallis test used for statistical testing

Variable	Microbial organism isolated in infective endocarditis in the US				
	Staphylococcus (213,287, 50.6%)	Streptococcus (105,692, 25.1%)	Enterococcus (40,712, 9.7%)	Gram-negative (25,762, 6.1%)	Polymicrobial (36,426, 8.6%)
Age (Years), Median (IQR)	57 (42−72)	63 (49−76)	67 (53−77)	61 (47−75)	62 (47−76)
Female	90,607 (42.5%)	36,337 (34.4%)	13,451 (33.0%)	12,468 (48.4%)	16,096 (44.2%)
White	130,638 (61.2%)	68,257 (64.6%)	27,445 (67.4%)	15,260 (59.2%)	23,050 (63.3%)
Black	31,121 (14.6%)	10,411 (9.9%)	4,582 (11.3%)	4,212 (16.3%)	5,071 (13.9%)
Hispanic	15,249 (7.1%)	7,861 (7.4%)	2,375 (5.8%)	1,936 (7.5%)	2,565 (7.0%)
Diabetes mellitus	58,726 (27.5%)	23,403 (22.1%)	11,668 (28.7%)	7,181 (27.9%)	9,891 (27.2%)
ESRD	36,996 (17.3%)	5,417 (5.1%)	4,183 (10.3%)	3,590 (13.9%)	4,097 (11.2%)
Drug Abuse	43,866 (21.0%)	9,290 (9.0%)	4,320 (11.0%)	3,378 (13.4%)	5,082 (14.4%)
Cancer	8,769 (4.1%)	5,725 (5.4%)	2,597 (6.4%)	1,351 (5.2%)	2,094 (5.7%)
Pacemaker/ ICD	10,212 (4.8%)	5,879 (5.6%)	3,609 (8.9%)	1,269 (4.9%)	2,132 (5.9%)
Mortality	29,274 (13.8%)	8,123 (7.7%)	2,468 (6.1%)	2,820 (11.0%)	3,993 (11.0%)
Nursing home discharge	95,740 (45.0%)	41,087 (39.0%)	20,373 (50.2%)	11,711 (45.6%)	17,815 (49.0%)
Single valve surgery	15,569 (7.3%)	12,134 (11.5%)	4,198 (10.3%)	2,217 (8.6%)	3,360 (9.2%)
Multiple valve surgery	3,139 (1.5%)	3,631 (3.4%)	1,300 (3.2%)	480 (1.9 %)	821 (2.3%)
Septic shock	29,823 (14.0%)	8,092 (7.7%)	1,465 (3.6%)	3,701 (14.4%)	4,337 (11.9%)
Cost of stay in US dollar, Median, (IQR)	23,928 (12,845-48,095)	18,246 (10,283-39,667)	18,984 (10,743-39,713)	24,358 (12,950-50,561)	22,999 (12,264-49,304)

All p values in the above univariate analysis were <0.05. IQR: interquartile range, ICD: implantable cardioverter defibrillator, ESRD: end stage renal disease.

population being a possible explanation. Limitations of our study include—lack of proper validation studies of ICD codes for IE, lack of imaging data and lack of speciation of Staphylococcus.

In conclusion, Staphylococcus was the most common organism isolated in IE in the US and was associated with increased in-hospital mortality, length of stay, and cost of care. We also report an upward trend in Enterococcal IE during the study period – a finding that needs further study.

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Declaration of Interests

The authors declare that they have no known competing financial interests or personal relations that could have appeared to influence the work reported in this study.

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Relation of Malnutrition to Outcome Following Orthotopic Heart Transplantation

There are approximately 2,200 orthotopic heart transplant (OHT) surgeries performed annually in the United States.[1] Most of the recipients are chronically ill with long-standing heart failure, and a prevalence of malnutrition ranging from 35% to 57%.[2] The decision surrounding candidacy is based on a careful assessment of risk (including malnutrition) and benefits, and in many cases, OHT may proceed despite underlying malnutrition. Data regarding the outcomes of patients with malnutrition receiving OHT are limited. We performed a retrospective cohort study using the Nationwide Inpatient Sample (2012 to 2015) to assess the impact of malnutrition on outcomes after OHT.

We used the International Classification of Diseases Ninth Edition Clinical Modification codes to identify all adult patients (age > 18) with and without malnutrition who underwent OHT. Data regarding baseline and demographic characteristics, as well as outcomes including in-hospital mortality, cost of hospitalization, length of stay, sepsis, and acute kidney injury were extracted. Weighted multivariate logistic regression was performed to assess the impact of malnutrition on OHT outcomes after adjusting for all baseline co-morbidities.

A total of 7,940 patients underwent OHT. Of those, 1,515 (19.1%) had malnutrition. Malnourished patients were more likely to be admitted to large urban teaching hospitals, belong to the lowest socio-economic quartile, have an underlying coagulopathy (51.8% vs 42.9%, $p < 0.01$) as well as fluid and electrolyte disorders (77.2% vs 64.4%, $p < 0.01$), but less likely to have hypertension, diabetes mellitus, dyslipidemia, chronic lung disease, and other co-morbidities. With regard to outcomes, patients with documented malnourishment had higher rates of in-hospital mortality (8.9% vs 5.3%, $p < 0.001$), sepsis (31.0% vs 13.5%, $p < 0.001$), acute kidney injury requiring dialysis (4.6% vs 3.6%, $p < 0.001$), and need for any form of mechanical circulatory support (MCS) (35.6% vs 18.4%, $p < 0.001$). They also had, on average, a two-fold longer length of stay and a 1.5-fold higher cost of hospitalization ($p < 0.01$). After adjusting for all baseline co-morbidities, malnutrition was an independent predictor of all-cause in-hospital mortality (odds ratio [OR]: 1.74, 95% confidence interval [CI]: 1.08 to 2.80, $p < 0.001$).

OHT is one of the most "high-stake" solid organ transplants and care providers do their best to optimize these patients for surgery and reduce their risk of adverse events postoperatively. However, there are limited trial data assessing the impact of malnutrition on OHT outcomes. This study found that patients with malnutrition had higher prevalence of co-morbid conditions such as fluid and electrolyte disorders, and coagulopathy, which could potentially be contributing to worse outcomes. We also found that the group with malnutrition had higher proportion of Africa-American (20.8% vs 18.4%, $p < 0.05$) patients, and those belonging to the lower income quartile (26.1% vs 21.5%, $p < 0.01$). These factors may represent a poor socio-economic support system, which is often an important consideration while deciding the candidacy for OHT. Malnourishment in advanced heart failure is frequent and may be multifactorial, secondary to an increased systemic inflammatory response, congestive gastropathy leading to a protein-losing enteropathy, and heightened levels of circulating catecholamines. Whether judicious use of mechanical circulatory assist devices to improve nutritional status and perioperative risk, beyond intense nutritional support and physical rehabilitation, can help improve outcomes and organ utilization remains an elusive question that needs to be answered in future studies.

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