Predicting Outcomes in Two-Stage Exchange Arthroplasty for Periprosthetic Joint Infection: A Retrospective Review of Neutrophil-to-Lymphocyte Ratio and C-Reactive Protein

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INTRODUCTION: Periprosthetic joint infection (PJI) remains one of the most catastrophic complications in total joint arthroplasty. PJI is a challenge to diagnose, with no absolute confirmatory test, and carries significant medical and economic implications when treated. Historically, the gold standard surgical management for PJI has been a two-stage exchange arthroplasty. To date, no adequate predictive model exists for determining patient outcomes when undergoing a two-stage exchange. The authors in our study suggest that the neutrophil-to-lymphocyte ratio (NLR), along with other previously reported studies on serum biomarkers, such as C-reactive protein (CRP), are of predictive significance in assessing patient outcomes in the gold standard treatment for PJI. The purpose of this study was to investigate the ability of serum biomarkers NLR and CRP to correctly delineate between successful outcomes versus clinical failure and mortality.

METHODS: After Institutional Review Board approval, a cohort of 334 patients with ≥2 positive cultures for PJI were identified via microbiological specimen banking between February 2020 and March 2022. All patients who underwent the first stage of a two-stage exchange for a first time infected total knee (TKA) or total hip (THA) arthroplasty with ≥1 year of clinical follow up or definitive failure were enrolled in the study. Preoperative values were retrospectively collected for NLR and CRP. Postoperatively, the same values were collected with closest proximity to postoperative day 30. Patient outcomes were determined at their latest follow up with a minimum 1-year requirement or a definitive failure; they were classified according to the Musculoskeletal Infection Society's Outcome Reporting Tool for PJI into success (tiers 1/2), failure (tiers 3D/3E/3F), and mortality groups (tier 4A). Statistical investigation included demographic data and receiver operating characteristic (ROC) curve analysis. Furthermore, Charlson Comorbidity Index (CCI) and body mass index (BMI) were collected and compared between outcome groups.

RESULTS:

From the cohort of 334 total patients, 73 patients met inclusion criteria, with 40 (55%) males, 33 (45%) females, 38 (52%) TKAs, and 35 (48%) THAs. At the time of analysis, 59 (81%) patients were still living, and 14 (19%) patients were deceased with mortality ≤1-year post PJI surgery. Based on strict criteria 22 (30%) patients were classified into the success group, 37 (51%) patients were classified into the failure group, and the remaining 14 (19%) patients were enrolled into the mortality group. Outcomes were determined with an average follow up of 664 days for patients with successful outcomes, 495 days for patients with clinical failures, and 42 days for patients in the mortality group.

Average CCI of the mortality group was significantly different compared to the success group with CCIs of 5.50 and 3.32 respectively (p-value <0.01). ROC analysis of CCI comparing success and mortality groups demonstrated an area under the curve (AUC) of 0.800 (95% Confidence Interval (CI): 0.657-0.943; p-value <0.01).The results of the ROC curve analysis when evaluating clinical success versus failure showed that the AUC for preoperative NLR and CRP was 0.623 (95% CI: 0.482-0.770) and 0.703 (95% CI: 0.563-0.843; p-value <0.01), respectively, while the AUC for postoperative NLR and CRP was 0.533 (95% CI: 0.381-0.686) and 0.672 (95% CI: 0.532-0.812), respectively (Fig. 1). When evaluating clinical success versus mortality, the ROC curve analysis indicated that the AUC for preoperative NLR and CRP was 0.753 (95% CI: 0.585-0.922) and 0.849 (95% CI: 0.719-0.974; p-value <0.01), respectively, while the AUC for postoperative NLR and CRP was 0.822 (95% CI: 0.670-0.973; p-value <0.01) and 0.828 (95% CI: 0.657-0.999; p-value <0.01), respectively (Fig. 2).

Clinically relevant cutoffs were identified via the Youden Index (J-index) when comparing postoperative data between success and mortality groups. J-index for NLR was 57.0 (sensitivity 61.5%; specificity 95.5%) with a cutoff of 4.92, while J-index for CRP was 70.5 (sensitivity 75%; specificity 95.5%) with a cutoff of 27 mg/L.

DISCUSSION AND CONCLUSION: NLR has been reported in literature to be of prognostic significance in a variety of clinical applications. In this study, we showed a similar trend. Our data suggested that NLR is of prognostic importance and should be evaluated as a stand-alone value and in combination with other serum biomarkers, most notably CRP, for determining outcomes in PJI management. Our best predictive model was found to be in delineating outcomes of clinical success and mortality, demonstrating that these markers could potentially be used to inform patients and their families regarding perioperative risks when undergoing a two-stage exchange for PJI. Our study adds to the clinical decision tree in PJI management by providing a readily attainable and relatively low-cost predictive assessment into patient mortality when undergoing a two-stage exchange for PJI management. Predicting outcomes in PJI treatment is advantageous when making treatment decisions and will provide future insight into optimal reimplantation time following the first stage of a two-stage exchange, the latter of which could prove invaluable in facilitating clinical success.

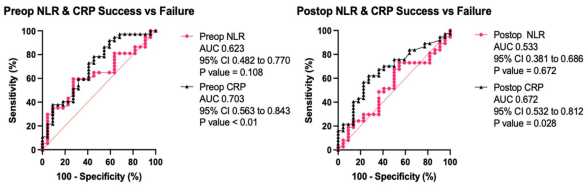

Figure 1. Clinical Success vs Failure. ROC curve analysis of the predictive value of NLR and CRP, preoperative (preop) and postoperative (postop). ROC: receiver operator characteristic; NLR: neutrophil-to-lymphocyte ratio; CRP: C-reactive protein.

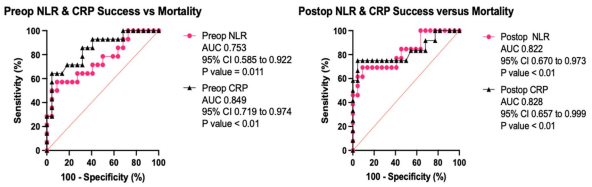

Figure 2. Clinical Success vs Mortality. ROC curve analysis of the predictive value of NLR and CRP, preoperative (preop) and postoperative (postop). ROC: receiver operator characteristic; NLR: neutrophil-to-lymphocyte ratio; CRP: C-reactive protein.