

Another critical limitation of this study is that the PREVENT III study was not designed to capture all the resources that patients incur in the care of their CLI. Length of stay and NOR are proxies for RU that are easy to understand and generalize. We have not performed cost accounting for actual materials, equipment, and professional time used during these hospitalizations. Those data are not available from the PREVENT III study. We have also not accounted for rehabilitation resources, visiting nurses, family contributions, loss of labor by the patient, and many other direct and indirect resources in preparation for revascularization and during the year afterward. Such precise accounting is beyond the scope of this study, although it is the authors' future intent to explore these areas by using financial and economic tools.

In summary, this study found that TL was highly associated with increased RU in early and later time periods. The effect of early GRE was significant in early RU but diminished in later time periods. GRE in later periods incurred greater RU in subsequent time periods. Several patient demographics and comorbidities were also associated with RU, including dialysis-dependent renal failure, older age, hypertension, and nonwhite race. Our findings may have implications for patient care and health care policy. Prevention of TL through patient and physician education, better foot care, or earlier detection of peripheral arterial disease may decrease RU. Similarly, early GREs are commonly attributed to technical problems, and thus efforts to reduce such events through training or process improvements may also reduce RU. Mid-term graft failure is common and also incurs significant RU; hence, the development of novel strategies to reduce the frequency of vein graft disease would have important benefits to the health care system. Finally, our findings further underscore the significant care needs of CLI patients beyond their revascularization procedure, and current resource allocations for this patient population may need to be re-examined.

## CONCLUSIONS

Several patient-specific factors, including dialysis-dependent renal failure, older age, hypertension, and nonwhite race, have important effects on RU during the first postoperative year. Stage of disease at presentation (TL) and sustained patency of the bypass graft (freedom from GRE) are also critical determinants of RU in limb salvage surgery. These effects predominate early (iLOS) and persist through 1 year.

## AUTHOR CONTRIBUTIONS

Conception and design: LLN, MSC

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## INVITED COMMENTARY

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The authors are to be congratulated on the foresight to include measures of resource utilization in a prospective, randomized, multicenter clinical trial. The authors tracked the initial, or index, length of stay, the number of rehospitalizations, and the cumulative hospital length of stay following vein bypass procedures

for critical limb ischemia. Tissue loss and graft-related events were associated with greater resource utilization. Among comorbidities and patient demographics, dialysis and hypertension had an effect on both an early and cumulative use of resources, whereas nonwhite race had an effect on cumulative length of stay.

The increasing cost of health care and the resulting oversight of the entire health care industry by government, politicians, and third party payers have made outcomes increasingly important. Hospital management has reacted by decreasing the number of hospital beds, consolidating services, and focusing on standardization. The importance, however, of balancing quality of care (as measured by outcomes such as graft patency, limb salvage, and perioperative morbidity and mortality), quality of life (as measured by quality-of-life surveys and functional assessment), patient satisfaction, and resource utilization (as measured by cost, length of stay, and incidence of rehospitalization) cannot be overemphasized. Studies are already reporting on the relationship between surgical volume and outcomes, as well as the per capita rates of revascularization and the choice of revascularization procedures. Critical to future studies will be the ability to compare data. If concerns for cost and resource utilization are not to adversely affect quality of care, we must develop appropriate measures of each.

Risk-adjusted morbidity and mortality rates are already being reported by the Veterans Health Administration (VHA). The VHA developed the National Surgical Quality Improvement Program, which is the standard for risk-adjusted assessment of surgical outcomes. The model allows the prediction of surgical outcomes and permits a comparative assessment of outcomes among facilities with varying patient populations.

To date, the vascular literature has progressed from descriptive and technical articles to those providing measures of surgical outcome, such as graft patency, limb salvage, and quality of life. Vascular surgery took an early lead in the identification of tools such as life-table patency and the standardization of clinical measures. Quality-of-life assessment and the development of subjective and functional measures of quality of life are under development. At present, only crude measures of resource utilization exist. Length of stay and rehospitalization are gross measures, at best. Cost measures are probably not currently comparable between institutions because of the myriad of accounting variables, not the least of which is the variability in efficiency across organizations. Some organizations simply have work and care processes with more waste and inefficiencies than others.

Because hospital and hospital-related costs now represent one of the largest components of total health care expenditure, those factors that affect hospital resource utilization, such as length of stay, patient risk factors, and perioperative morbidity, will become

increasingly important. Length of stay and the rate of rehospitalization are perhaps the best defined and the easiest to measure. Even these simple measures, however, can be affected by local variables such as the availability of home health care and rehabilitation and extended-care facilities. Studies incorporating cost will be more complex to develop, especially when multiple institutions are involved. Shackley et al<sup>1</sup> have previously discussed the costing of vascular surgery. It is generally agreed that direct, and not indirect, costs should be assessed. Direct costs include staffing, consumables and supplies, laboratory and diagnostic testing, and pharmaceuticals. In reporting costs, hospital charges should not be used. Costs should be expressed as a dollar value but ideally should include the quantity and unit cost as well, to account for local variations. Other options to assess financial resource utilization across hospitals or regions might incorporate the use of Medicare or insurer databases to track total payouts in relevant areas such as hospital, outpatient, or diagnostic costs. Fisher et al<sup>2</sup> employed such strategies using the Medicare database.

Studies that combine clinical outcomes, cost, and quality of life to assess resource utilization and the value of clinical pathways, standardized management protocols, and efforts to reduce variability will become increasingly important. Kresowik and associates<sup>3,4</sup> have already demonstrated the ability to assess intrastate and interstate process and outcomes and to demonstrate improvement in outcomes with the confidential feedback of provider measures. This study, by Nguyen and associates, represents one of the first efforts to assess resource utilization in a multicenter study, and it should provide the impetus for further efforts and innovation.

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