PROGRAM PROFILE

Multidisciplinary Amputation Prevention at the DeBakey VA Hospital: Our First Decade

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Background: In 2011, the Veterans Health Administration (VHA) undertook multidisciplinary efforts to improve care for patients with nonhealing foot ulcers and reduce leg amputation rates. This article examines the impact of interdisciplinary care for amputation prevention in the VHA.
Methods: The VHA patient population was characterized using internal registries. Texas hospital admission data were used to identify sex and zip-code matched cohorts. VHA provided data on national and local frequencies of various amputations and the number of patients with diabetes.
Results: Compared to matched nonveteran patients, veterans treated at VHA hospitals were older and more often self-identified as Black. They also had significantly higher rates of diabetes, chronic kidney disease, and systolic heart failure. A decrease from 160 to 66 amputations per 100,000 was seen from 2012 to 2017 (a 60% reduction) after implementing interdisciplinary care. Several evidence-directed practices were implemented during the study period. The proportion of angiograms for foot ulcers or gangrene increased from 28.9% to 90.9%.
Conclusions: Interdisciplinary care can significantly reduce leg amputation rates. This reduction does not seem dependent on a particular model for providing inpatient care.

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Individuals with diabetes are at risk for developing foot ulcers or full-thickness defects in the epithelium of the foot. These defects can lead to bacterial invasion and foot infection, potentially resulting in leg amputation (Figure 1). Effective treatment to prevent leg amputation, known as limb salvage, requires management across multiple medical specialties including podiatry, vascular surgery, and infectious diseases. The multidisciplinary team approach to limb salvage was introduced in Boston in 1928 and has been the prevailing approach to this cross-specialty medical problem for at least a decade.[1,2]

The Michael E. DeBakey Veterans Affairs Medical Center (MEDVAMC) has established an inpatient limb salvage program—a group of dedicated clinicians working collaboratively to provide evidence-guided management of patients hospitalized with foot ulcers, foot gangrene or any superimposed infection with the goal of avoiding leg amputations. We have seen a significant and durable reduction in the incidence of leg amputations among veterans at MEDVAMC.

This article describes the evolution and outcomes of the MEDVAMC limb salvage program over more than a decade. It includes changes to team structure and workflow, as well as past and present successes and challenges. The eAppendix provides a narrative summary with examples of how our clinical practice and research efforts have informed one another and how these findings are applied to clinical management. This process is part of the larger efforts of the Veterans Health Administration (VHA) to create a learning health system in which "internal data and experience are systematically integrated with external evidence, and that knowledge is put into practice."[3]

METHODS

Data from the VHA Support Service Center were used to obtain monthly major (leg) and minor (toe and partial foot) amputation records at MEDVAMC from October 2000 through May 2023. Yearly totals for the number of persons with diabetes and foot ulcers at MEDVAMC were also obtained from the support service center. Annual patient population sizes and number of persons with foot ulcers were converted to monthly estimates using cubic spline interpolation. Rates were calculated as 12-month rolling averages. Trend lines were created with locally weighted running line smoothing that used a span α of 0.1.

We characterized the patient population using data from cohorts of veterans treated for foot ulcers and foot infections at MEDVAMC. To compare the contemporary veteran population with nonveteran inpatients treated for foot ulcers and foot infections at other hospitals, we created a 2:1 nonveteran to veteran cohort matched by sex and zip code, using publicly available hospital admission

TABLE. Changes Introduced to Amputation Prevention and Limb Salvage at MEDVAMC; 2011-2023

	Preventative	Treatment of disease		End-stage complications	
Goal	Primary prevention	Foot reconstruction, wound healing	PAD identification and management	Infection treatment	Leg amputation system of care
Created	Prevention/awareness letters sent to moderate and high-risk veterans in zip codes either remote from experienced medical centers or with large differences in amputation rates by race	Delayed primary closure for minor amputations after revascularization	Objective testing for PAD for all patients with foot ulcers Noninvasive testing to corroborate normal pulse examination and with no pedal medial artery calcification Angiography for everyone else	Aggressive treatment for Gram negative (esp. pattern C polymicrobial) infection Repeating bone biopsy for treatment failure Empiric vancomycin only if MRSA nasal colonization or abscess Cardiology evaluation if new acute cardiac complications are seen	Postoperative rivaroxaban and vascular medicine consultation to reduce long-term mortality
Adopted	A 500-word educational brochure, translated into many languages	Split-thickness skin grafting to the foot Total contact casting Hydrosurgical debridement Outpatient negative pressure therapy for foot ulcers Ostectomies without amputating the associated toe	Spliced (composite) vein conduits for lower extremity bypasses Routine use of distal vein patches for tibial bypassess with PolyTetraFluoroEthylene Outpatient-based angiograms, endovascular intervention Pedal arterial access Carbon dioxide angiography for patients with advanced chronic kidney disease 3-dimensional angiography Microscope-aided plantar and plantar branch artery bypasses	Preferred surgical treatment of osteomyelitis Preferred microbial culture-guided antibiotics over empiric therapy Preferred for oral antibiotics for osteomyelitis treatment Iodosorb ointment instead of wet-to-dry dressings Negative pressure therapy with instillation	Pirigoff and Syme ankle-level amputations Through-knee amputations Regional nerve blocks as the default anesthetic
Employed and introduced	FTEs for 2 additional podiatrists Temperature-sensing mats to identify preulceration skin inflammation	Same-day prosthetics dispensing of offloading footwear MediHoney added to pharmacy formulary	Standardized consult template Standardized inpatient orders	Direct pager for inpatient foot infection consults	Preoperative physical therapy and psychology consultations

Abbreviations: FTE, full time equivalent; MEDVAMC, Michael E. DeBakey Veterans Affairs Medical Center; MRSA, methicillin-resistant Staphylococcus aureus; PAD, peripheral artery disease.

data from the Texas Department of Health and State Health Services. Veterans used for this cohort comparison are consistent with the 100 consecutive patients who underwent angiography for limb salvage in 2022.

This research was approved by the Baylor College of Medicine Institutional Review Board (protocol H-34858) and the MEDVAMC Research Committee (IRBNet protocol 15A12. HB). All analyses used deidentified data in the R programming language version 4.2.2 using RStudio version 2022.06.0 Build 421.

PROGRAM DESCRIPTION

MEDVAMC is a 350-bed teaching hospital located in central Houston. Its hospital system includes 11 outpatient clinics, ranging from 28 to 126 miles (eAppendix, Supplemental Figure A) from MEDVAMC. MEDVAMC provides vascular, orthopedic, and podiatric surgery services, as well as many other highly specialized services such as liver and heart transplants. The hospital's risk-adjusted rates of operative morbidity and mortality (observed-to-expected ratios) are significantly lower than expected.

Despite this, the incidence rate of leg amputations at MEDVAMC in early 2011 was nearly 3-times higher than the VHA average. The inpatient management of veterans with infected foot ulcers was fragmented, with the general, orthopedic, and vascular surgery

FIGURE 1. Schematic Diagram Illustrating the Disease Spectrum of Diabetic Foot Disease

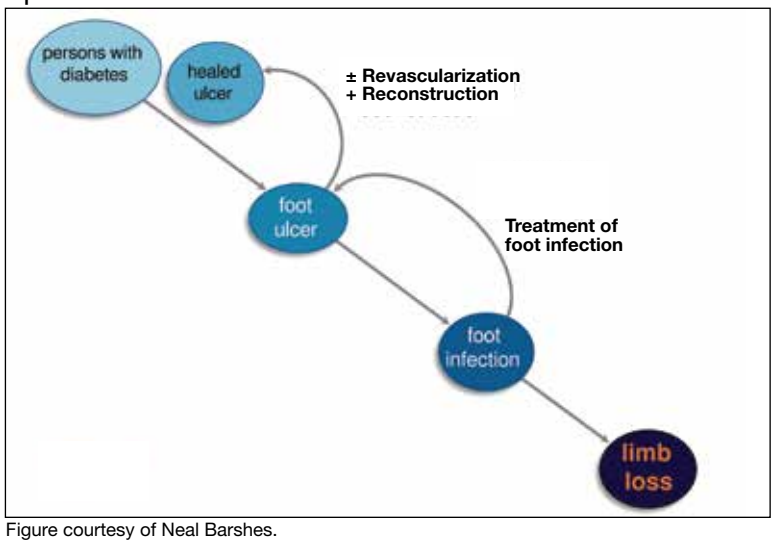


Figure courtesy of Neal Barshes.

teams separately providing siloed care. Delays in treatment were common. There was much service- and practitioner-level practice heterogeneity. No diagnostic or treatment protocols were used, and standard treatment components were sporadically provided.

Patient Population

Compared to the matched non-VHA patient cohort (Supplemental Table 1), veterans treated at MEDVAMC for limb salvage are older. Nearly half (46%) identify as Black, which is associated with a 2-fold higher risk-adjusted rate of leg amputations.[4] MEDVAMC patients also have significantly higher rates of diabetes, chronic kidney disease, and systolic heart failure. About 22% travel > 40 miles for treatment at MEDVAMC, double that of the matched cohort (10.7%). Additionally, 35% currently smoke and 37% have moderate to severe peripheral artery disease (PAD).[5]

PROGRAM DESIGN

In late 2011, the MEDVAMC vascular surgery team led limb salvage efforts by implementing a single team model, which involved assuming the primary role of managing foot ulcers for all veterans, both infected and uninfected (eAppendix, Supplemental Figure B). Consultations were directed to a dedicated limb salvage pager. The vascular team provided interdisciplinary limb salvage management across the spectrum of disease, including the surgical treatment of infection, assessment for PAD, open surgical operations and endovascular interventions to treat PAD, and foot reconstruction (debridement, minor or partial foot amputations, and skin grafting). This care was complemented by frequent consultation with the infectious disease, vascular medicine, podiatry, and geriatric wound care teams. This approach streamlined the delivery of consistent multidisciplinary care.

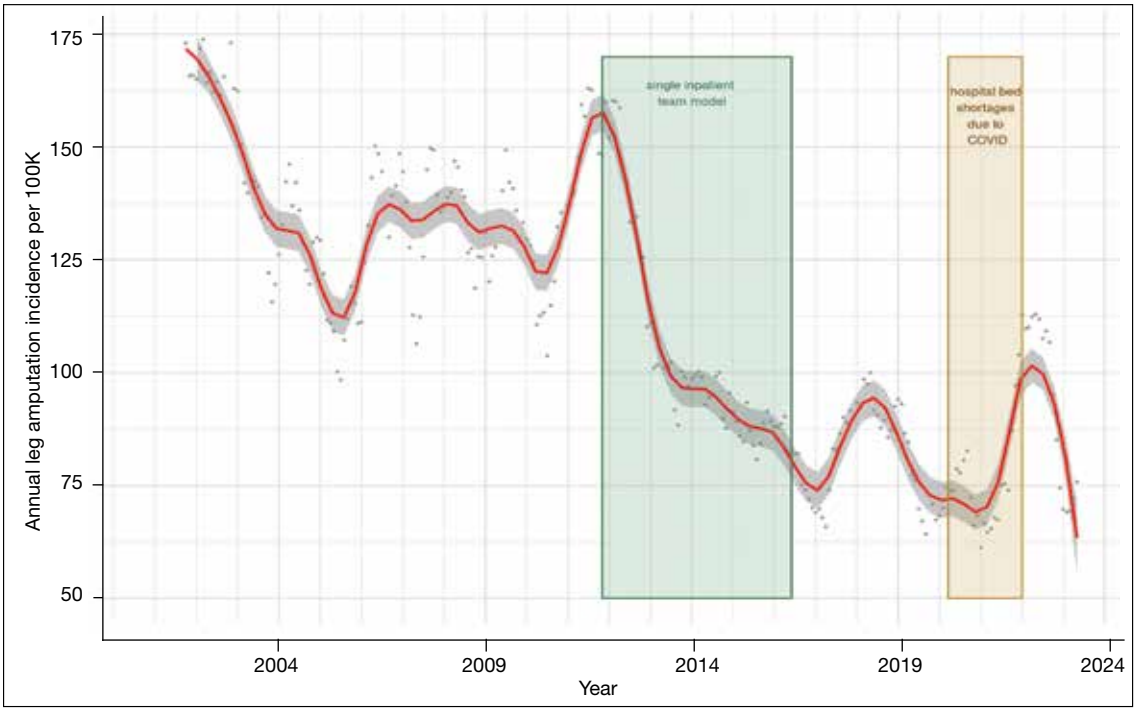
This collaborative effort aimed to develop ideal multidisciplinary care plans through research spanning the spectrum of the diabetic foot infection disease process (eAppendix, Supplemental Table 1). Some of the most impactful practices were: (1) a proclivity towards surgical treatment of foot infections, especially osteomyelitis[5]; (2) improved identification of PAD[6,7]; (3) early surgical closure of foot wounds following revascularization[8,9]; and (4) palliative wound care as an alternative to leg amputation in veterans who are not candidates for revascularization and limb salvage.[10] Initally, the vascular surgery team held monthly multidisciplinary limb salvage meetings to coordinate patient management, identify ways to streamline care and avoid waste, discuss research findings, and review the 12-month rolling average of the MEDVAMC leg amputation incidence rate.

During the study period, the MEDVAMC vascular surgery team consisted of 2 to 5 board certified vascular or general surgeons, 2 or 3 nurse practitioners, and 3 vascular ultrasound technologists. Associated specialists included 2 podiatrists, 3 geriatricians with wound care certification, as well as additional infectious diseases, vascular medicine, orthopedics, and general surgery specialists.

PROGRAM ASSESSMENT

We noted a significant and sustained decrease in the MEDVAMC leg amputation rate after implementing multidisciplinary meetings and a single-team model from early 2012 through 2017 (Figure 2). The amputation incidence rate decreased steadily over the period from a maximum of 160 per 100,000 per year in February 2012 to a nadir of 66 per 100,000 per year in April 2017, an overall 60% decrease. Increases were noted in early 2018 after ceasing the single-team model, and in the summer of 2022, following periods of bed shortages after the onset of the COVID-19 pandemic. Tracking this metric allowed clinicians to make course corrections.

FIGURE 2. Major Amputation Incidence Rates at MEDVAMC Among Veterans With Diabetes, 2001-2023



Abbreviation: MEDVAMC, Michael E. DeBakey Veterans Affairs Medical Center.

The decreased leg amputation rate at MEDVAMC does not seem to be mirroring national or regional trends. During this 10-year period, the VHA annualized amputation rate decreased minimally, from 58 to 54 per 100,000 (eAppendix Supplemental Figure C). Leg amputation incidence at non-VHA hospitals in Texas slightly increased over the same period.[11]

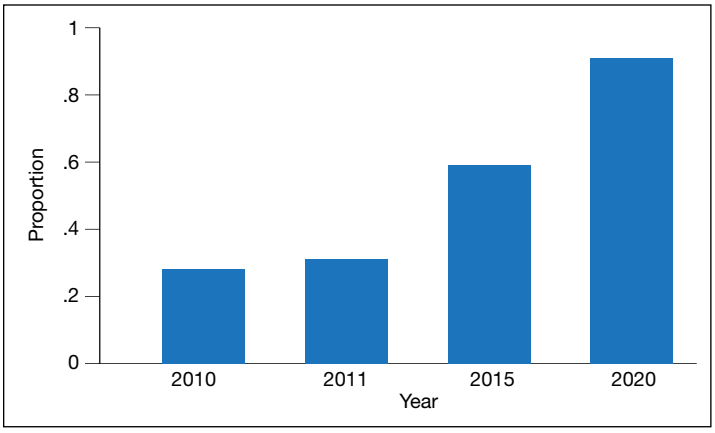
Value was also reflected in other metrics. MEDVAMC improved safety through a bundled strategy that reduced the risk-adjusted rate of surgical wound infections by 95%.[12] MEDVAMC prioritized limb salvage when selecting patients for angiography and nearly eliminated using stent-grafts, cryopreserved allogeneic saphenous vein grafts, and expensive surgical and endovascular implants, which were identified as more expensive and less effective than other options (Figure 3).[13-15] The MEDVAMC team achieved a > 90% patient trust rating on the Veterans Signals survey in fiscal years 2021 and 2022.

Challenges

A significant increase in the patient-physician ratio occurred 5 years into the program. In 2016, 2 vascular surgeons left MEDVAMC and a planned renovation of 1 of the 2 vascular surgery-assigned hybrid working facilities began even as the number of MEDVAMC patients with diabetes grew 120% (from 89,400 to 107,746 between 2010 and 2016), and the incidence rate of foot ulcers grew 300% (from 392 in 2010 to 1183 in 2016 per 100,000). The net result was a higher clinical workload among the remaining vascular surgeons with less operating room availability.

To stabilize surgeon retention, MEDVAMC reverted from the single team model back to inpatient care being distributed among general surgery, orthopedic surgery, and vascular surgery. After noting an increase in the leg amputation incidence rate, we adjusted the focus from multidisciplinary to interdisciplinary care (ie, majority of limb salvage clinical care can be provided by practitioners of any involved specialties). We worked to establish a local, written, interdisciplinary consensus on evaluating and managing veterans with nonhealing foot ulcers to mitigate the loss of a consolidated inpatient approach. Despite frequent staff turnover, ≥ 1 physician or surgeon from the core specialties of vascular

FIGURE 3. Proportion of Diagnostic Angiography for Limb Salvage vs Other Indications at MEDVAMC



Abbreviation: MEDVAMC, Michael E. DeBakey Veterans Affairs Medical Center.

surgery, podiatry, and infectious diseases remained throughout the study period.

The COVID-19 pandemic caused a shortage of hospital beds. This was followed by more bed shortages due to decreased nursing staff. Our health care system also had a period of restricted outpatient encounters early in the pandemic. During this time, we noted a delayed presentation of veterans with advanced infections and another increase in leg amputation incidence rate.

Like many health systems, MEDVAMC pivoted to telephone- and video-based outpatient encounters. Our team also used publicly available Texas hospitalization data to identify zip codes with particularly high leg amputation incidence rates, and > 3500 educational mailings to veterans categorized as moderate and high risk for leg amputation in these zip codes. These mailings provided information on recognizing foot ulcers and infections, emphasized timely evaluation, and named the MEDVAMC vascular surgery team as a point-of-contact. More recently, we have seen a further decrease in the MEDVAMC incidences of leg amputation to its lowest rate in > 20 years.

DISCUSSION

A learning organization that directs its research based on clinical observations and informs its clinical care with research findings can produce palpable improvements in outcomes. Understanding the disease process and trying to better understand management across the entire range of this disease process has allowed our team to make consistent and systematic changes in care (Table). Consolidating inpatient care in a single team model seems to have been effective in reducing amputation rates among veterans with diabetes. The role the MEDVAMC vascular surgery team served for limb salvage patients may have been particularly beneficial because of the large impact untreated or unidentified PAD can have and because of the high prevalence of PAD among the limb salvage population seen at MEDVAMC. To be sustainable, though, a single-team model needs resources. A multiteam model can also be effective if the degree of multidisciplinary involvement for any given veteran is appropriate to the individual's clinical needs, teams are engaged and willing to contribute in a defined role within their specialty, and lines of communication remain open.

The primary challenge at MEDVAMC has been, and will continue to be, the retention of physicians and surgeons. MEDVAMC has excellent leadership and a collegial working environment, but better access to operating rooms for elective and time-sensitive operations, additional clinical staff support, and higher salary at non-VA positions have been the basis for many of physicians–especially surgeons–leaving MEDVAMC. Despite high staff turnover and a constant flow of resident and fellow trainees, MEDVAMC has been able to keep the clinical approach relatively consistent due to the use of written protocols and continuity of care as ≥ 1 physician or surgeon from each of the 4 main teams remained engaged with limb salvage throughout the entire period.

Going forward, we will work to ensure that all requirements of the 2022 Prevention of Amputation in Veterans Everywhere directive are incorporated into care.[8] We plan to standardize MEDVAMC management algorithms further, both to streamline care and reduce the opportunity for disparities in treatment. More prophylactic podiatric procedures, surgical forms of offloading, and a shared multidisciplinary clinic space may also further help patients.

CONCLUSIONS

The introduction of multidisciplinary limb salvage at MEDVAMC has led to significant and sustained reductions in leg amputation incidence. These reductions do not seem dependent upon a specific team structure for inpatient care. To improve patient outcomes, efforts should focus

on making improvements across the entire disease spectrum. For limb salvage, this includes primary prevention of foot ulcers, the treatment of foot infections, identification and management of PAD, surgical reconstruction/optimal wound healing, and care for patients who undergo leg amputation.

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The authors report no actual or potential conflicts of interest with regard to this article.

Disclaimer

The opinions expressed herein are those of the authors and do not necessarily reflect those of *Federal Practitioner,* Frontline Medical Communications Inc., the US Government, or any of its agencies.

Ethics and consent

Approved by Baylor College of Medicine Institutional Review Board (protocol H-34858) and the Michael E. DeBakey Veterans Affairs Medical Center Research Committee (IRBNet protocol 15A12.HB).

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