Diabetic Foot Algorithm For Proper Treatment and Triaging Diabetic Foot Ulcers

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Statement of Purpose

With healthcare costs and Diabetes prevalence on the rise, we theorize a novel approach for diabetic foot care for implementation across multiple specialties in a hospital setting.

Level of Study

Level 4 Retrospective Study

Introduction

Diabetes Mellitus has recently eclipsed to a top 4 prevalent co-morbidity throughout the world. In America, 30.3 million citizens suffer from diabetes consisting of 9.4% of the population. With prevalence on the rise, it is no surprise to be encountered even more so from a podiatric standpoint. Diabetic patients are at risk for increased complications from a podiatric perspective. Foot complications are rampant consisting of neuropathy, vascular compromise, musculoskeletal issues, and wounds. Wounds are more problematic as co-morbidities such as Charcot, DVT, and infection are often misrepresented or misdiagnosed. Hospitalist and specialty guidelines for initial treatment of diabetic patients with wounds differ by training and hospital with no real current standard approach to care. We theorize a novel technique for the evaluation of osteomyelitis in a hospital setting.

Methods

We retrospectively analyzed 22 patient charts in hopes of reviewing care techniques to see if the approach and outcome to patient care was optimized. Each patient was diabetic with neuropathy who presented with a wound to the LE. Each patient underwent various laboratory studies, was evaluated clinically, and had advanced imaging obtained which include plain radiographs, MRI, CTs, and WBC scans. The manner and order of each exam was also studied in hopes of ensuring adequate patient care. Each imaging result was also studied to quantify the accuracy of the varying modalities. If the ulcer probed to bone, the algorithm became simpler as based on clinical findings such as elevated WBC, ESR, and presence of purulence, less diagnostic imaging was required. We theorize our diabetic foot ulcer algorithm may be applied to diabetic foot care with improved outcomes in cost and patient management.

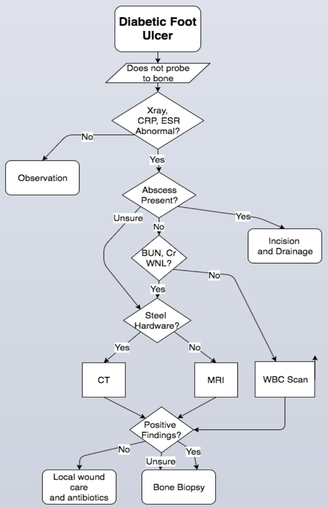

Figure 1: Proposed DFU Algorithm

Results

In total, twenty-two patients were reviewed. Out of the twenty-two patients, eighteen patients were identified as having "mis-steps" or an incompetency in their testing approach and timeline based on our algorithm. As a result, these patients experienced extended hospital stays, increased costs, and unnecessary procedures. Three patients out of the twenty-two presented with advanced imaging orders for MRI or WBC scan following which were read as positive for osteomyelitis after a thorough work up corresponding with the proposed algorithm. Following a procedure involving bone biopsy, each of the patients were found to have osteomyelitis on pathology. A total of twelve patients received advanced imaging prior to clinical exam or radiographic images with eight of these patients having definitive osteomyelitis on plain film. In the majority of these cases, the advanced imaging was not clinically indicated and was a waste of resources. In four cases, CTs were ordered as the first study prior to acquiring clinical exam or other imaging studies. Only one of these patients with CT as the first procedure had any contra-indication to other imaging modality. CT proved to be an unreliable modality at first defense in this small sample size. Two of the four CT patients eventually went on to additional advanced imaging and bone biopsy with positive results for osteomyelitis. There was one patient who underwent clinical and laboratory exam who required advanced imaging based on our proposed algorithm. This patient also received a MRI which was read as positive for osteomyelitis. A bone biopsy was performed which revealed negative results on pathology for osteomyelitis. There were two patients who received a WBC scan who demonstrated clinical signs of infection including purulent drainage and a wound which probed to bone. There were no radiographic findings of osteomyelitis. Each patient received a WBC which was read as positive for osteomyelitis, however, only one of the patients had pathology verify the results.

In case one as documented below, a patient presented with a plantar forefoot wound. Patient was admitted to a local hospital and had a CBC, BMP, and ESR drawn. Both the CBC and ESR were in normal limits. Upon clinical exam, the wound did not probe to bone and lacked any signs of local infection such as purulent drainage, warmth, and erythema. Radiographs of the foot were obtained which were read as negative for osteomyelitis. A MRI was pursued for advanced imaging. Following the MRI, results were read as osteomyelitis with marrow edema to the midfoot amputation remnants. Due to this, a revisional procedure was performed including a wound resection with bone biopsy of multiple regions. Upon completion and review of pathology, there was no osteomyelitis identified. In this situation, there were no clinical, laboratory, or radiographic findings of osteomyelitis, however, advanced imaging was pursued which led to an additional procedure and increase in patient cost for an overall negative result. This patient would have benefitted from having the proposed algorithm as a MRI would not have been pursued, and the patient would not have had an extended hospital stay or an arguably unnecessary procedure.

When reviewing our algorithm and applying it to the patients studied, eighteen would have benefited due to the reduction in cost and additional procedures performed. Three patients received adequate care course based on our algorithm. One patient followed our algorithm standard of care but received negative results for osteomyelitis contrary to the expected outcome.

Clinical Condition: Suspected Osteomyelitis of the Foot in Patients with Diabetes Mellitus

Variant 4: Soft-tissue swelling with neuropathic arthropathy and ulcer.

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	9	Initial study. Radiographs and MRI are complementary, and both are indicated. The results of initial x-ray examination do not preclude the necessity for additional studies.	☢
MRI foot without and with IV contrast	9	Radiographs and MRI are complementary, and both are indicated. MRI is useful preoperatively to identify the extent of involvement and to map devitalized areas.	O
MRI foot without IV contrast	9	Radiographs and MRI are complementary, and both are indicated.	O
Labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan foot	3		☢☢☢☢
Labeled leukocyte scan foot (In-111 or Tc-99m)	1		☢☢☢☢
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) foot	1		☢☢☢☢
Tc-99m 3-phase bone scan foot	1		☢☢☢
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan foot	1		☢☢☢☢
CT foot without IV contrast	1		☢
CT foot without and with IV contrast	1		☢
CT foot with IV contrast	1		☢
US foot	1		O
FDG-PET/CT foot	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Figure 2: Current Radiology Guidelines For DFU Evaluation

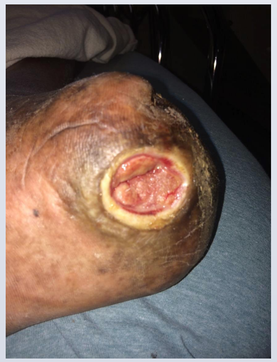

Figure 3: Left foot DFU

Figure 4: X-Ray of left foot DFU with negative findings for osteomyelitis

Digure 5: MRI of left foot DFU read as osteomyelitis

Pathology

BONE, SITE NOT OTHERWISE SPECIFIED, BIOPSY:

- BONE WITH FATTY MARROW IS HISTOLOGICALLY VIABLE AND WITHOUT INFLAMMATORY INFILTRATES.

- NO EVIDENCE OF OSTEOMYELITIS IN THIS SPECIMEN.

- NEGATIVE FOR MALIGNANCY OR ATYPICAL FEATURES.

Figure 6: Pathology report for DFU revealing no osteomyelitis

Discussion

Diabetic foot wounds are a large component of podiatric care, and these wounds become even more complicated in trying to identify deep space and bone infections. Current radiographic approaches may not be optimized in these situations as specificities and sensitivities vary and are hindered if inappropriately used. The respective specificities and sensitivities for Bone Scans, X-Rays, and MRIs are 45% and 86%, 67% and 60%, and 67% and 81%. Even expected gold standards are less than ideal as recent studies have shown the concordance between bone pathology and microbiology to identify osteomyelitis is 41.4 %. Due to this, complications such as increased costs, improper imaging, or inadequate care may occur more frequently than desired. Literature has also shown a clinical unreliability in the analysis of osteomyelitis in the diabetic foot wound. The highest correlation between imaging modalities has been documented at 62% between radiographs and MRI. There are too many situations where these advanced modalities may produce a false positive result. There is always a concern for biomechanical changes or arthropathy which may cause bone marrow changes and fatty infiltration which can mimic the pathological finds of osteomyelitis. With a need to improve and advance efforts in reliability and identification of osteomyelitis, we are hopeful our algorithm based on clinical, radiographic, and laboratory data will serve as a useful tool moving forward for diabetic foot care with respect to wounds.

In addition to standards for advanced imaging, there are also radiographic usage regulations implemented by the American College of Radiology. Each hospital has a standard of care where physicians may refer to guidelines for advanced imaging as pictured in the results section under Figure 2. Physicians may follow these regulations based on patient symptoms such as wounds, swelling, and neuropathy. For a diabetic patient with a wound, swelling, and neuropathy, advanced imaging via X-Ray and MRI are listed first while other modalities such as a WBC scan are given less weight. For a diabetic patient with no neuropathy, a CT is given the highest standard of care at a 9 with MRI and X-Ray in a lower bracket. While neuropathy is a huge symptom in diabetics, the lack of neuropathy should not alter the standard of care and implementation of certain advanced imaging. Physicians basing their recommendations and orders on these guidelines are allowing opportunities for a "mis-step" by our standards.

We acknowledge a small sample size within this retrospective review despite our positive results and implementation of our algorithm. In spite of this, we believe our fully encompassing algorithm based on laboratory studies, clinical exam, and advanced imaging may serve as a positive influence on the care of diabetic foot wounds if implemented.

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