Diabetic Wound Healing Experience in the Rural Health Care Setting

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Abstract:

Complications associated with diabetic foot ulcerations and the related co-morbid conditions are becoming a pandemic. With the worldwide number of diabetic patients reaching well into the hundreds of millions, the impact and burden on healthcare systems is felt on a global scale. Previous investigations have demonstrated the benefits of coordinating care on a multi-disciplinary level to improve outcomes in the care of this high risk patient group. There are, however, many geographic regions underserved by specialists, and a supplementary effort must be expended by the medical and nursing staff available to ensure favorable outcomes. Herein, the authors hope to share the results achieved at a rural health system wound healing program with limited specialty services.

Key words: Foot ulcer, ulceration related co-morbid conditions.

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Introduction

The economic impact of diabetes cannot be understated, with estimates projected into the hundreds of billions of dollars annually, much of which is biased towards the treatment of diabetic foot complications.[1-3]

Prior investigators have recognized the efficacy of a multi-disciplinary team approach while treating neurotrophic ulcers, which are all too often associated with infections, peripheral arterial disease, malnutrition, poor glycemic control and foot deformities.[2, 4-7] In the overall measure of outcomes there are two ultimate endpoints: 1) Healing of the ulcer or 2) Amputation. It has clearly been shown that diabetes is the leading cause of non-traumatic lower extremity amputations year after year.[8-10] A significant effort is therefore warranted to prevent limb loss, as the physiologic advantages to limb preservation have been demonstrated in both cardiovascular energy expenditure and mortality rates.[4, 9, 11]

With these considerations in mind, it becomes readily apparent that preventing ulceration, infection, and potential amputation is a priority. Attaining and maintaining a stable limb for ambulation may be challenging to providers in a rural setting where access to specialists and facilities is challenging. Herein the authors hope to provide a review of the current literature, epidemiology of diabetes-related lower extremity morbidity and mortality, as well as presenting a few challenging cases with emphasis on limited-resource treatments.

Year	Worldwide Prevalence[10] Population (%)	United States Prevalence[21] Population (%)
2000[22]	171x10^6 (2.8)	17.7 x10^6 (6.2)
2030[22]	366 x10^6 (4.4)	30.3 x10^6 (7.5)

Table 1 Worldwide and United States Prevalence of Diabetics.

Epidemiology

Despite the amount of attention paid to diabetes in the national and local news, it continues to be a growing pandemic *(Table 1*). Worldwide, the percentage of persons diagnosed with diabetes continues to rise, but is still relatively low compared to those in the United States (U.S.). Presently the U.S. more than doubles the global prevalence of diabetes with an estimated 7.8% (23.6 million people). Of those, 17.9 million are currently diagnosed with diabetes, with an additional 5.7 million who remain undiagnosed and therefore untreated.[8]

Unfortunately, the trend in the U.S. is toward even higher numbers of persons with diabetes in the future.[10] The prevalence of diabetes in America has increased 13.5% from the years 2005-2007.[8] This represents part of a three fold increase in the number of persons with diabetes from 1980 to 2006.[12] So, while treatment and maintenance of diabetes in the current population is our primary concern, prevention should be more heavily emphasized.

Diabetic ulcers are a common and expensive problem (*Table 2*). With a 0.5% to 3% annual cumulative incidence of diabetic foot ulcers, an estimated 15% of patient with diabetes will develop a lower extremity ulcer during the course of their disease.[2] Health care expenses are also a concern with 24% of total costs for diabetics being ulcer-related.[13] The onset of a diabetic ulcer also statistically predisposes the patient to subsequent wounds, amputations, and lifelong health problems.

Treating chronic wounds is certainly time consuming and expensive; adittionally, they can herald more advanced disease and health problems, including its associated mortality and cardiovascular risk.

Estimated total annual expenditures, both direct and indirect, for diabetes management in 2007 was $174 billion, accounting for 1 out of every 10 health care dollars spent in the United States.[14] (*Table 2*) The average total costs of treatment for diabetic foot ulcers or diabetes-related amputations are significant. These costs add to the burden of treating this disease and in some ways determine the level of care a patient receives. Chronic management and acute exacerbations are challenges, but more concerning is the “economic prognosis” for these patients. The long term cost of treatment for amputations or diabetic ulcers, including subsequent ulcers, new amputations, and home care, dwarfs the short term costs. The care of diabetes is, therefore, not only a significant fiscal burden to national healthcare, but also to the individual with medical or surgical complications. With so many resources invested after treatment for a diabetic ulceration, long term multidisciplinary follow up should be a priority.

A major contribution to these costs is increased frequency of hospital admissions as well as extended hospital stays. Treatment of infected foot wounds comprises up to one quarter of all diabetic hospital admissions in the U.S. and Britain.[15] A long term study in the United Kingdom found the length of hospital stay for diabetic patients with foot problems was twice that of non-diabetic patients with the same diagnosis.[16]

Direct Costs:	Diabetes Care:	**$27 Billion** *Individual Immediate Cost*[23]* *Diabetic ulcer: $7,500* *Amputation: $50,000*
	Chronic Diabetes Related Complications:	**$58 Billion** *Individual Long Term Costs†[24]:* *Diabetic Ulcer:* *$16,100-26,700* *Amputation:* *$43,000-63,000*
	Excess General Medical Costs:	**$31 Billion**
Direct Subtotal:		**$116 Billion**
Indirect Costs:‡		**$58 Billion**
Total Costs:		**$174 Billion****[14]

Table 2 Direct and Indirect Costs of Diabetes.

*Immediate Costs: Cost for hospital care, antibiotics, surgery, out-patient care, staff attendance, drugs and material for ulcer dressings, and orthopaedic appliances. Adjusted to 1990 US Dollars

**This is a 32% increase since 2002, which means the dollar amount has risen over $8 billion more each year.

†Long Term Costs: Subsequent ulcers, new amputations, and home care. Adjusted to 1994 US Dollars.

‡Indirect Costs: Increased absenteeism, reduced productivity, disease related unemployment or disability, loss of productive capacity due to mortality.

Given this evidence, diabetic patients may find themselves quickly in economic distress, especially for individuals with lower tiered income.

Unfortunately, the greatest concern is not the expense of treatment, but the human cost of poor glycemic control. Amputation is a drastic yet frequently necessary treatment option for diabetic persons with severe lower extremity complications (*Table 3*). The need for amputation is a poor prognostic indicator, made worse with the need for a major amputation versus a minor amputation.

Those patients in need of an index major amputation are at higher risk for mortality, new major amputations, lower rehabilitation potential, and have equal rates of new amputations (regardless of level), than those with index minor amputations.[17]

Commensurate with long standing diabetes is another deadly complication, cardiovascular disease. Heart disease and stroke account for about 65% of deaths in people with diabetes. The death rate secondary to heart problems is about 2 to 4 times higher than adults without diabetes.

Focus of Research	Primary Outcomes
Worldwide Mortality[25]	$2.9x10^6$ (5.2%)
United States Mortality[25]	$2.24x10^5$ (8%)
Excess Mortality in World's Poorest Countries*[25]	2-3%
5 year Survival After Ulceration in Diabetes[11]	43-55%
5 year Survival After Amputation in Diabetes[11]	28-31%
Ulceration Requiring Amputation[2]	Non-Diabetic 7-20%
	Diabetic 85%
Incidence of LEAs per 10^5 Persons[26]	Non-Diabetic 1.6
	Diabetic 46.1

Table 3 Mortality Rates Worldwide with Diabetic Foot Ulcers or Amputation. *Poorest Countries: Selected African Countries, Cambodia, Laos, Myanmar, Vietnam.[2, 8, 11, 25, 27]. LEA – Lower Extremity Amputation.

Likewise, the chance of stroke is 2 to 4 times higher in diabetic persons than those without diabetes; not only is their likelihood of having a stroke higher, their chances of death from stroke are 2.8 times that of their peers.[8]

In regard to the present study population, the lead author's Wound Healing program is located in a rural setting, at a community based hospital. The demographics of the surrounding counties are listed and demonstrate an incidence of diabetes two percent higher than the national average. *(Table 4)*

The program is staffed by one general surgeon and three podiatric surgeons with a supporting nursing staff. There is no board certified infectious disease specialist in any of the three adjacent counties, and the nearest vascular surgeon is affiliated with a hospital system 20 miles away. Thus, our staff is challenged to be very aggressive in treatment and must work closely with the primary care physicians and medical staff at our facility. Fortunately for this program, there is a certified pedorthist who is able to provide essential services in regard to accommodative orthoses, bracing and offloading devices. These coordinated efforts have led to an overall wound healing rate of 92%, which is at or above par for reported chronic wound healing.[18-20]

These outcomes are exemplified by our low occurrence of limb loss. Out of 414 new patients evaluated and treated in 2008-2009, only two patients had an end-point of trans-tibial amputation. Both are after very protracted illnesses and exhaustive wound care efforts.

Case Presentations

Case #1

A 65 year old male with insuling requiring Type 2 diabetes presented with a neurotrophic ulcer on the plantar aspect of his right foot. (Fig. 1) He did have palpable pedal pulses albeit diminished secondary to edema and venous insufficiency. His medical history was also significant for DM with peripheral neuropathy, hypercholesterolemia, venous stasis, and obesity. His relevant past surgical history included previous partial amputation of his right 2nd digit by another provider. The index ulcer was present for 3 months prior to evaluation at the wound healing program. In subsequent treatments he had failed offloading, maintenance debridement, and multiple variations in dressing types. With no progress toward healing of the wound after several weeks, the decision was made to proceed with surgical intervention.

	County		
Demographic Data	Blair	Bedford	Huntingdon
Population[21]	125,527	49,650	45,556
Median Household Income[21]	$41,646	$38,257	$39,866
Population Over 65[21]	21,465	8,639	7,152
Diabetic Population[28]	9,514 (9.9%)*	3,633 (9.5%)	3,511(9.9%)

Table 4 Demographics of surrounding counties. * 2.1% higher than the national average.

Figure 1 (Patient #1) Presenting neurotrophic ulcer.

This included a tenotomy of the 4th digit long extensor tendon as well as a percutaneous tendoachilles lengthening (TAL) and a rotational transpositional flap for wound coverage. (Fig. 2a-b) By 4 months post-operatively he was ambulating with a completely healed wound and had improved his glycosylated hemoglobin to 6.4%. (Fig. 3)

Subsequently, after discharge to long term follow up, he presented with a new ulcer on the plantar aspect of the ipsilateral heel. (Fig. 4)

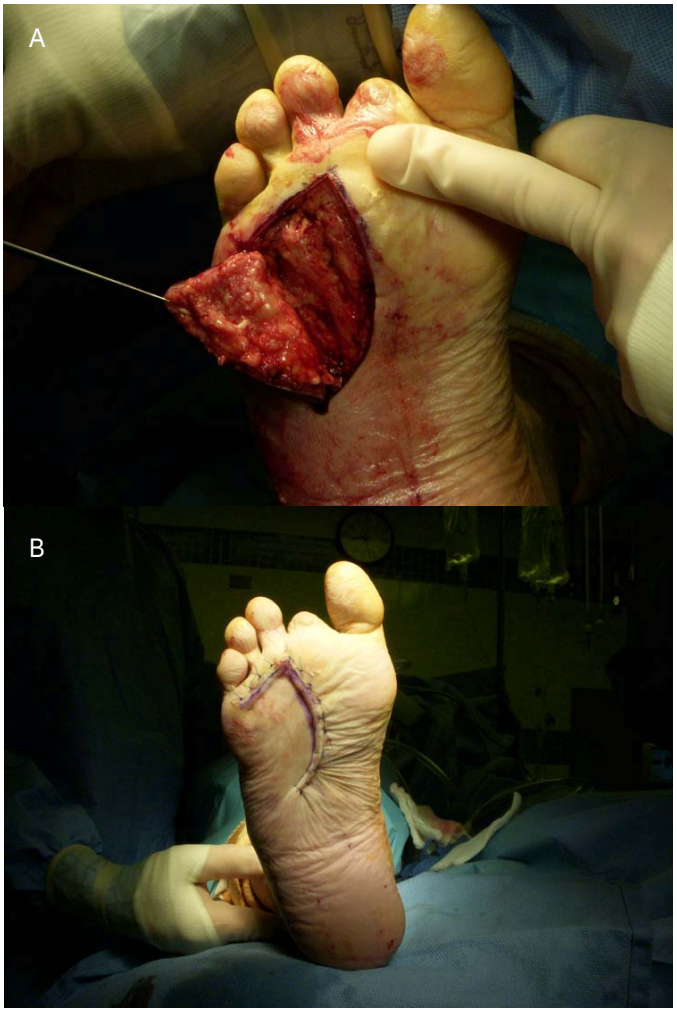

Figure 2 (Patient #1) Intra-operative photo demonstrating creation of a full thickness transpositional flap on the plantar foot (a). Immediate post-operative photo demonstrating closure of the wound (b).

Figure 3 (Patient #1) Four month post-operative photo demonstrating complete resolution of the wound.

Figure 4 (Patient #1) Long-term follow-up with a new plantar heel ulcer.

Figure 5 (Patient #1) Application of Apligraf® to the wound.

Figure 6 (Patient #1) Final long term follow up with both wounds healed.

Figure 7 (Patient #2) Pre-operative radiograph.

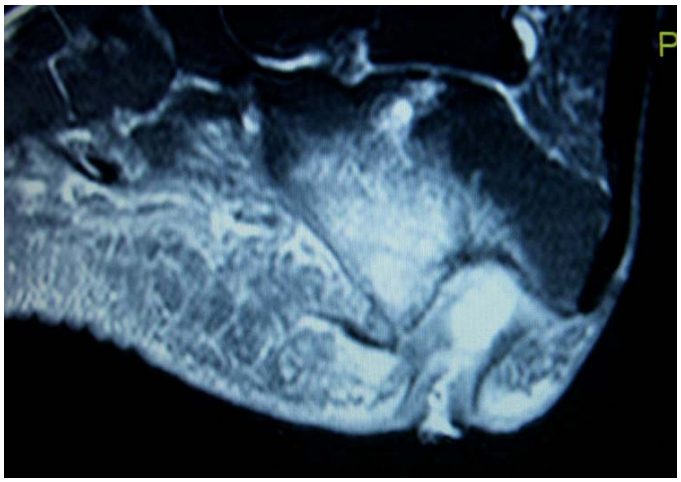

Figure 8 (Patient #2) Pre-operative MRI. Note the large sinus tract and sequestrum in the calcaneal tuberosity.

After months of continued treatments with a variety of modalities including debridement, negative pressure wound therapy (Wound VAC, KCI, San Antonio, Tx), and Apligraf® (Organogenesis Inc, Canton, MA) (Fig. 5), as well as offloading with a patellar tendon weightbearing brace, the wound was finally closed. He is now ambulating in the community with extra-depth shoes and accommodative inserts. (Fig. 6)

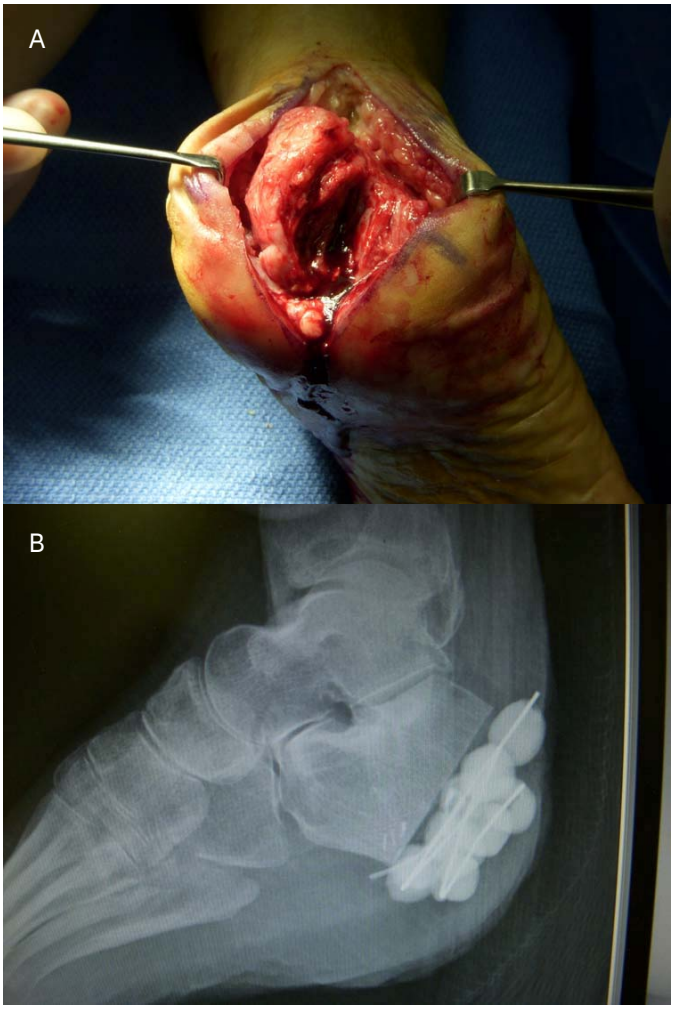

Figure 9 (Patient #2) Intra-operative photo demonstrating the extent of the osseous destruction and depth of the sequestrum. (a) Post-operative radiograph demonstrating the extent of bone resection and antibiotic cement beads. (b)

Case #2

A 66 year old female presented with an ongoing history of an open ulcer on her right heel for approximately two years. Her surgical history was complicated as a result of iatrogenic neuropathy after total hip arthroplasty. She had previously been treated conservatively by providers in a large metropolitan hospital with no resolution and had a persistent draining sinus and ulcer. Radiographs and an MRI were obtained. (Figs. 7-8)

Figure 10 (Patient #2) Clinical photo at 3 weeks post-operative.

Aggressive therapy being indicated, and she was admitted for broad spectrum intravenous antibiotics, incision and drainage and a concomitant subtotal calcanectomy (Fig. 9). The index procedure was performed in conjunction with implantation of antibiotic beads. Intra-operative cultures of the bone indicated *Proteus mirabilis* and directed antibiotic therapy was begun. Subsequently, a delayed primary closure was performed which included removal of the antibiotic beads and excision of a clean margin of the calcaneus. No further pathogens were identified, and the wound healed within 3 weeks. (Fig. 10) She has now been fully functional with a patellar tendon weightbearing brace for over 14 months with no recurrence and minimal functional limitations. (Fig. 11)

Figure 11 (Patient #2) Demonstration of the patellar tendon weightbearing brace after wound healing.

Case #3

A fifteen year old male presented with a wound and severe abscess on the plantar left foot which had been present for approximately one week.(Fig. 12) He was a morbidly obese male (BMI = 40.2) with impaired glucose tolerance that had been managed by his primary care physician (PCP) with oral hypoglycemics. The wound had begun as a callus which the patient tried to "chew" off with his teeth. He was evaluated at a local emergency room a few days prior to his initial exam and placed on oral amoxicillin/clavulanate. Upon presentation to the office he was immediately admitted for incision, and drainage with administration of broad spectrum antibiotics were ordered. Post-operatively the residual wound was covered with a Wound VAC® (KCI, San Antonio, TX) and intra-operative cultures demonstrated methicillin-sensitive *Staphylococcus aureus* and he was continued on intravenous cefazolin. After a few days he was returned to the operating room for excisional debridement with partial primary wound closure; the VAC® was maintained until he could follow up at the Wound Healing Program.

Figure 12 (Patient #3) Clinical photo at presentation with large abscess.

The intention was to perform outpatient application of Apligraf®; however, with continued improvements and daily dressing changes consisting of Cellerate Powder™ (Wound Care Innovations, LLC, Fort Lauderdale, FL) the wound healed within 5 weeks. (Fig. 13)

Conclusions

Herein the authors have demonstrated the success possible in a wound healing program with limited specialty services. Although a multidisciplinary "team" approach to the diabetic foot has been demonstrated as an effective treatment model and should be employed where feasible, a close working relationship with a patient's PCP is always a priority. This, when combined with an aggressive wound care program, can result in equal outcomes in a rural setting. The wound healing team must maintain an added level of diligence in their care and monitor for any and all indications of diabetic foot complications.

Figure 13 (Patient #3) Clinical photo 5 weeks after 2 procedures (index incision and drainage followed by excisional debridement with application of Wound VAC®) and treatment with Cellerate™ powder.

References

1. Chow I, Lemos E, Einarson T. Management and prevention of diabetic foot ulcers and infections: a health economic review. *Pharmacoeconomics* 2008;26(12):1019-35.
2. Frykberg R, Armstrong D, Giurini J et al. Diabetic foot disorders: aclinical practice guideline. *J Foot Ankle Surg* 2006;45(5 Supp):1-66.
3. Rogers L, Lavery L, Armstrong D. The right to bear legs – an amendment to healthcare: how preventing amputations can save billions for the US healthcare system. *J Am Podiatr Med Assoc* 2008;98(2):166-8.

4. Apelqvist J, Larsson J. What is the most effective way to reduce incidence of amputation in the diabetic foot? *Diabetes Metab Res Rev* 2000;Supp 1:S75-S83.
5. Brem H, Sheehan P, Rosenberg H, Schneider J, Boulton A. Evidence based protocol for diabetic foot ulcers. *Plast Reconstr Surg*.
2006;117(7 Supp):210S-1S.
6. Lipsky B, Berendt A, Deery H et al. Diagnosis and treatment of diabetic foot infections. *Clin Infect Dis* 2004;39(7):885-910.
7. Penny H, Webster N, Sullivan R, Spinazzola. A multidisciplinary appraoch to a possible limb-threatening infection. *Adv Skin*
Wound Care 2008;21(12):564-7.
8. American Diabetes Association. www.diabetes.org . 2009. 3-26-2009. Ref Type: Internet Communication.
9. Johannesson A, Larsson G, Ramstrand N, Turkiewicz A, Wirehn A, Atroshi I. Incidence of lower-limb amputation in the diabetic and non-diabetic general population: a 10 year population based cohort study of initial unilateral and contralateral amputations and reamputations. *Diabetes Care* 2009;32(2):275-80.
10. World Health Organization. http://www.who.int/diabetes/en/ . 2009. 3-26-2009. Ref Type: Internet Communication.
11. Robbins J, Strauss G, Aron D, Long J, Kuba J, Kaplan Y. Mortality rates and diabetic foot ulcers: is it time to communicate mortality risk to patients with diabetic foot ulceration? *J Am Podiatr Med Assoc* 2008;98(6):489-93.
12. Department of Health and Human Services: Centers for Disease Control and Prevention. *Number of Persons with Diagnosed Diabetes, United States 1980-2006*. http://www.cdc.gov/diabetes/statistics/prev/national/figpersons.htm . 2009. 4-11-0009. Ref Type: Internet Communication.
13. Harrington C, Zagari M, Corea J, Klitenic J. A cost analysis of diabetic lower extremity ulcers. *Diabetes Care* 2000;1333-8.
14. American Diabetes Association. Indirect, Direct, and Total Costs of Treatment of Diabetes. http://www.diabetes.org/diabetes-statistics/cost-of-diabetes-in-us.jsp . 2009. 4-15-0009. Ref Type: Internet Communication.
15. Gibbons G, Eliopoulos G. *Infection of the diabetic foot.* In: Kozak G, Campbell R, Frykberg R, Habershaw G, editors. *Management of Diabetic Foot Problems*.Philadelphia: Saunders; 1995.
16. Currie C, Morgan C, Peters J. The epidemiology and cost of inpatient care for peripheral vascular disease, infection, neuropathy and ulceration in diabetes. *Diabetes Care* 1998;21:42-8.
17. Ragnarson G, Tennvall G, Apelqvist J. The economic cost of the diabetic foot. In: Faglia E, Guffrida G, Oriani G, editors. *The Ischemic Diabetic Foot*.Milan: Editrice Kurtice; 1999.
18. Margolis D, Kantor J, Berlin J. Healing of diabetic neuropathic foot ulcers receiving standard treatment. *Diabetes Care* 1999;22(5):692-5.
19. Ince P, Game F, Jeffcoate W. Rate of healing of \ neuropathic ulcers of the foot in diabetes and its relationship to ulcer duration and ulcer area. *Diabetes Care* 2007;30(3):660-3.
20. Kantor J. Expected healing rates for chronic wounds. *Wounds* 2000;12(6):155-8.
21. United States Census Bureau. http://www.census.gov/index.html . 2007. 4-12-2009. Ref Type: Internet Communication.
22. Wild S, Roglic G, Green A, Sicree R, King H. Global Prevalence of Diabetes. *Diabetes Care* 2004;27(5):1047-53.
23. Apelqvist J, Ragnarson G, Persson U, Larsson G. Diabetic foot ulcers in a multidisciplinary setting - an economic analysis of primary healing and healing with amputation. *J Intern Med* 1994;235:463-71.
24. Apelqvist J, Larsson J, Ragnarson G, Persson U. Long-Term Costs for Foot Ulcers in Diabetic Patients in a Multi-\ Disciplinary Setting. *Foot Ankle* 1995;16:388-94.
25. Roglic G. The Burden of Mortality Attributable to Diabetes. *Diabetes Care* 2005;28(9):2130-5.
26. Calle-Pascual A, Redondo M, Ballesteros M, Martinez-Salinas M, Diaz J, et al. Nontraumatic lower extremity amputations in diabetic and nondiabetic subjects in Madrid, Spain. *Diabetes Metab* 2009;23(6):519-23.
27. Faglia E, Favales F, Morabito A. New ulceration, new major amputation, and survival rates in diabetic subjects hospitalized for foot ulceration from 1990 to 1993. *Diabetes Care* 2001;24:78.
28. Department of Health and Human Services: Centers for Disease Control and Prevention. http://apps.nccd.cdc.gov/ddstrs/default.aspx . 2009. 4-12-2009. Ref Type: Internet Communication.