Effects of foot complications in patients with Type 2 diabetes mellitus on public healthcare: An analysis based on the Korea National Diabetes Program Cohort

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ABSTRACT

Aim: Diabetes mellitus (DM) patients are susceptible to foot injury or foot diseases such as diabetic foot and peripheral arterial disease. Although these conditions are considered important, few studies have investigated them in detail. Therefore, we investigated the epidemiology of diabetic foot complications (DFC) with respect to the effects on the public healthcare system.

Methods: We evaluated the incidence, clinical characteristics, health service utilization frequency and medical expenses of DFC in type 2 DM patients in the Korea National Diabetes Program (KNDP), the largest multi-center, prospective cohort in Korea (n = 4405). To determine precise outcomes, we used national representative databases, including claims data from the Health Insurance Review & Assessment Service of Korea.

Results: During a median follow-up period of 3.30 years, 528 patients (12.0%) were newly diagnosed with DFC at an incidence rate of 43.02 cases per 1000 person-years. The patients with DFC were significantly older than patients without DFC, but other clinical characteristics were similar between the two groups. The patients with DFC had more hospital visits ($p < 0.001$), longer duration of hospitalization ($p < 0.001$), and increased expenses ($p < 0.001$) compared to patients without DFC. After multiple adjustments, the differences in number of hospital visits and medical expenses were consistent. In a before and after comparison within the DFC group, all three variables increased significantly after the onset of DFC ($p < 0.001$).

Conclusions: DFC were significantly associated with poor clinical outcomes and caused a substantial burden to the national healthcare system in Korea. Therefore, intervention to prevent DFC is important.

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1. Introduction

The number of patients with diabetes mellitus (DM) is increasing worldwide (Guariguata et al., 2014; Whiting et al., 2011). Korea is also part of this overall trend. According to an epidemiological investigation (Diabetes fact sheet in Korea, 2013), the number of DM patients over 30 years of age in Korea was approximately 4 million in 2011, which accounted for 1 in 8 adults. Also, 20% of adults in Korea were presumed to have impaired fasting glucose, which indicates that 1 in 3 Korean adults over 30 years of age is a DM patient or is at high risk for diabetes. The number of DM patients in Korea is predicted to rise to 6 million by 2050[1]. Increasing DM brings with it an increase in DM complications, inevitably leading to reduced quality of life among patients and increased medical expenses (Lesniowska et al., 2014; Pelletier et al., 2008).

Foot deformities are common in long-standing DM patients, who are prone to injury. These patients frequently do not recognize foot injuries due to hypoesthesia caused by diabetic neuropathy. Inappropriate wound care can further aggravate inflammation. Peripheral arterial disease (PAD) is a diabetic macrovascular complication that,

along with cardiovascular and cerebrovascular diseases, causes blood circulation disorders and leads to claudication, lower extremity amputation, and inflammation aggravation. Also, because cellular innate immunity dysfunction occurs in DM patients, such as that of polymorphonuclear cells, monocytes, and macrophages, the pathogenicity of some microorganisms can increase when blood glucose is high. In such cases, wound healing takes longer, and the wound becomes vulnerable to secondary infections, which can result in severe inflammation (Geerlings & Hoepelman, 1999). According to previous studies, the risk of cardiovascular and cerebrovascular diseases is high in DM patients with foot complications (Lai et al., 2014). However, DM patients with foot complications are often asymptomatic or complain of non-specific symptoms, and because foot complications are considered non-life-threatening, their clinical importance is frequently missed (Rooke et al., 2013). Considering their frequent occurrence, wide range of severity, secondary complications, and effect on patient prognosis, active prevention and treatment of foot complications in DM patients is expected to decrease mortality and morbidity and increase quality of life (Armstrong et al., 2014; Poredos et al., 2014). Therefore, it is clear that there is a need for an extensive study on foot complications in DM patients. PAD and diabetic foot are representative diabetic complications (Rhee & Kim, 2015). Many studies have investigated PAD and diabetic foot, but few have examined more general foot diseases that occur among DM patients.

In Korea, the only detailed study on the epidemiology of foot complications in DM patients is the investigative report published by the task force team (TFT) for the Epidemiology Committee of the Korean Diabetes Association in 2007 (Chung et al., 2006). In fact, there has not been any investigation on the epidemiology of foot complications in DM patients using a type 2 DM patient cohort. Thus, we defined the various foot complications in DM patients as diabetic foot complications (DFC) and investigated their epidemiological characteristics in Korean patients with type 2 DM using data from the Korea National Diabetes Program (KNDP), a large-scale prospective multicenter cohort of Korean patients with type 2 DM.

2. Subjects, materials, and methods

2.1. KNDP Cohort

Our study included patients from 12 hospitals who were enrolled in the KNDP cohort. KNDP cohort studies are prospective, multicenter, and observational studies that began in 2006 to expand the clinical and pathophysiological understanding of Korean patients with type 2 DM and those at high risk for diabetes. Type 2 DM was defined based on the diagnostic criteria set by the American Diabetes Association in 2004. The high risk group for diabetes was defined as having impaired fasting glucose, impaired glucose tolerance, or gestational diabetes. This study was performed as a project of the National Strategic Coordinating Center for Clinical Research by the Ministry of Health and Welfare. Participating hospitals included Kyung Hee University Hospital, Kyung Hee University Hospital at Gangdong, Korea University Guro Hospital, Ajou University Hospital, Inha University Hospital, Hanyang University Guri Hospital, Gachon Medical School Gil Hospital, Pusan National University Hospital, Kwandong University Cheil General Hospital and Women's Healthcare Center, Yeungnam University Medical Center, Inje University Sanggye Baik Hospital, and Hallym University Gangdong Sacred Heart Hospital. Medical history recording, physical examinations, laboratory tests, and surveys were performed. However, the surveys were not used in the current analyses because most of the contents were duplicates of the data from the Health Insurance Review & Assessment Service (HIRA). All of the data were recorded in the KNDP written case records and electronic case report forms (http://www.kndp.or.kr).

2.2. Study subjects

This study was performed on patients in the KNDP cohort whose clinical outcomes could be verified using claims data from HIRA.

Because only 5 years of data are provided to external investigators, the period of outcome observation was limited to the period from January 1, 2006 to December 31, 2010. The number of patients whose baseline characteristics were investigated during the corresponding period was 4407. Among these, two cases with improper matching were excluded, reducing the data analysis to 4405 patients. Among those patients, 318 who had been diagnosed with DFC before the study period began were also excluded, which further reduced the number of patients for final analysis to 4087 (Fig. 1).

2.3. Study methods

Patients were enrolled on a rolling basis between Jan. 2006 and Dec. 2010 and the baseline period was defined as the time of enrollment. The length of time between baseline and Dec. 2010 was defined as the follow-up period. This study analyzed clinical characteristics, number of hospital visits, length of hospital stay, and related medical expenses by combining KNDP cohort data and HIRA claims data from January 1, 2006 to December 31, 2010. The KNDP cohort data included basic clinical characteristics, risk factors for cardiovascular disease, medication history, biochemical examination, diabetic complications, and survey results. The basic clinical characteristics were age, gender, blood pressure, height, weight, and BMI. The risk factors for cardiovascular disease were hypertension, smoking, hyperlipidemia, heart failure, and arrhythmia. The medications were anti-diabetic, anti-hypertensive, anti-platelet, and anti-hyperlipidemic agents. Biochemical examinations for renal function, liver function, glycemic control, and lipid control were included. Examinations for diabetic microvascular complications such as diabetic nephropathy, diabetic neuropathy, and diabetic retinopathy and diabetic macrovascular complications such as cardiovascular disease, cerebrovascular disease, and PAD were also included. A survey was conducted on the history of hospital visits and dietary and lifestyle habits during the follow-up period. Clinical and biochemical parameters were measured annually. The data collected at the time of recruitment for the KNDP cohort were used as baseline characteristics, and baseline medical history such as hypertension, dyslipidemia, cardiovascular disease, cerebrovascular disease, and microvascular disease was analyzed on the basis of the KNDP baseline survey. The use of medication at baseline was determined depending on whether medication had been prescribed three months before KNDP registration for a duration longer than two months.

The HIRA claims database for the KNDP patients contained all healthcare utilization records generated between January 1, 2006, and December 31, 2010, and contained all relevant data: hospitalization, outpatient records, disease code based on the 6th version of the Korean Standard Classification of Diseases, prescription drugs and procedure codes, and fees. In our study, hospital visit number was defined as VST_DDCNT: the days visiting a medical care institution involving the first and second visit for an insurance recipient to receive medical care. The length of hospital stay was defined as VSCN, and medical expenses were defined as RVD_RPE_TAMT and included the doctor consultation fee, examination fee, internal prescription claim amount, and external prescription claim amount on external prescription details, which represented the total cost for both recipient and insurer.

DFC were defined on the basis of diagnostic codes (diabetic peripheral vascular disease, peripheral vascular disease, and foot disease) generated during the follow-up period in the HIRA data using the 6th version of the Korean Standard Classification of Diseases (Supplemental Table S1. The appropriate diagnostic codes are 100% compatible with the *International Classification of Diseases, 10th Revision*.

2.4. Statistical analysis

Clinical characteristics were expressed as means and standard deviations and compared between the DFC group and the non-DFC group using independent t-tests and chi-square tests. The incidence