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Original Research

Population-based study of venomous snakebite in Taiwan

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Abstract

Background: The epidemiological features of snakebite are fragmented and inadequate in most countries. The true impact of snakebite is also very likely to be underestimated, and reliable information on its incidence, morbidity, and mortality is limited worldwide.
Methods: We perform a nationwide epidemiological study of snakebite by extracting claim record data from Taiwan's National Health Insurance database to explore the epidemiology of venomous snakebite from years 2005 to 2009.
Results: A total of 4647 snakebites were reported in 2005–2009. The nationwide annual incidence of snakebite was 40.49 per million persons. Hemorrhagic-type snakebites (*Viridovipera stejnegeri* and *Protobothrops mucrosquamatus*) accounted for 71.78% of the cases, while neurotoxic-type snakebites (*Naja atra* and *Bungarus multicinctus*) accounted for 19.21%. Only a few cases of snakebites were caused by *Deinagkistrodon acutus* (0.73%). Although the east part of Taiwan accounted for only one-sixth of the total number of cases, the same area had the highest incidence of snakebite, about seven times the national incidence. Fifty-nine percent ($n = 2747$) of victims were between the age of 41 years and 70 years, and mostly in the age group of 51–60 years ($n = 1026$, 22%). The highest incidence (130.4 per million persons) was in the age group of 71–80 years. In general, snakebite victims suffered minor injuries. Overall, hospital admission was 35.8%, and only about 3.6% patients were needed to be admitted to the intensive care unit. During this study period, only two cases of mortality were documented.
Conclusion: In this population-based study, the annual incidence of venomous snakebite was 40 per million people. Cases of venomous snakebite are geographically unevenly distributed in Taiwan. Due to effective antivenom therapy, the outcome of the snakebite patients was favorable.
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Keywords: antivenom; epidemiology; snakebites

1. Introduction

There are very few wide-scaled epidemiological studies of snakebite. The true impact of snakebite is often underestimated, and trustworthy information on incidence, morbidity, and mortality is inadequate worldwide.[1,2] Population-based studies of incidence and mortality from snakebite are currently lacking and are urgently needed to investigate the full scale of the disease.[3] A Pacific subtropical island with mountains and forests, Taiwan is an ideal habitat for several species of snakes. However, similar to its neighboring tropical countries, a nationwide epidemiological study on snake envenomation is lacking. Epidemiological studies of snakebite in Taiwan were mostly conducted in a single hospital setting.[4] Therefore, it is very difficult to make conclusions pertaining to the need of antivenoms nationwide, the efficacy of such a therapy, and the scale of progress made on snakebite treatments.[5]

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There are six species of snakes throughout Taiwan that release deadly toxins, which can result in life-threatening complications. The four species of snakes in Taiwan that secrete hemorrhagic venom are *Viridovipera stejnegeri* (formerly *Trimeresurus stejnegeri*, Taiwan bamboo viper or green habu), *Protobothrops mucrosquamatus* (formerly *Trimeresurus mucrosquamatus,* Taiwan habu), *Deinagkistrodon acutus* (hundred-pacer), and *Daboia russelii siamensis*. These venoms cause local tissue swelling that can progress to severe compartment syndrome on the limb where venom was injected. In patients with severe tissue swelling, surgical intervention such as debridement, fasciotomy, or graft may be needed. Snakes releasing neurotoxic venoms are *Naja atra* (Chinese or Taiwan cobra) and *Bungarus multicinctus* (Taiwan banded krait). These venoms can cause respiratory distress due to muscle paralysis and other neurological manifestations such as diplopia, dysarthria, and extremity paralysis. Between the two species, *B. multicinctus* venoms result in a more profound neurological deficit than the venoms of *N. atra*. However, *N. atra* venoms can result in tissue damages as well as neurological deficits. Surgical intervention such as debridement, fasciotomy, or skin graft may also be needed in the treatment of *N. atra* snakebite.

In the 1960s, Taiwan began to develop antivenoms for some venomous snake species, but only about 15% of the cases were given antivenoms. At that time, most cases of snakebites were treated with herbal medicine instead.[6] In 1980s, the $F(ab')_2$ of horse immunoglobulin G antivenoms were developed by the Vaccine Center, Center for Disease Control, Taipei, Taiwan.[7–9] At present, four antivenom regimens are available in the country. The bivalent antivenom FH is effective against *V. stejnegeri* and *P. mucrosquamatus*, and another bivalent antivenom FN is effective against *B. multicinctus* and *N. atra*. The antivenom FA is effective against *D. acutus*. The antivenom FDrs that is effective against *D. russelii siamensis* was not developed until mid-2008.

Taiwan launched a single-payer National Health Insurance (NHI) program on March 1, 1995. According to the Bureau of NHI, the coverage of NHI has surpassed 96% of the national population, whereas the number of cooperating medical facilities has reached 95% in 2009.[10,11] The NHI database contains registration files and original claim data for reimbursement. After scrambling patients' identities, the database is provided to scientists in Taiwan for research purposes. With its nationwide coverage, it is pertinent for epidemiological studies and has been used widely in academic studies.[12] The purpose of this study was to perform a nationwide epidemiological study of venomous snakebite from 2005 to 2009. We intended to estimate the comprehensive epidemiological features of snake envenomation.

2. Materials and methods

2.1. Ethics statement

This study was approved by the Chang Gung Memorial Hospital Research Ethical Committee, Taoyuan, Taiwan (100−3049B). The identification of each patient was previously scrambled by the NIH Bureau; therefore, no informed consent was needed.

2.2. Data source and study methods

We used NHI claim data in the period of 2005−2009 for descriptive epidemiology studies. This data set included complete outpatient visits, hospital admissions, disease diagnosis, prescriptions, procedures, interventions, and vital statuses for the whole insured population. We established the longitudinal medical history of each beneficiary by linking several computerized administrative claim data sets to track the outcomes of the snakebite episodes. In the NHI database, each drug has its own drug code. By tracing the antivenom drug codes (drug codes J000006212 for FH, J000009212 for FN, and J000010209 for FA), we are able to retrieve cases treated by these antivenoms. As FDrs antivenom was not available prior to mid-2008, the cases that used FDrs antivenom were not included in this study. Patients who received only one type of antivenom for treatment were classified as FH group, FN group, or FA group, depending on the type of antivenom received. Patients who received more than one type of antivenom in a single episode of snakebite were classified as the mixed group.

Variables were extracted from the NHI database for descriptive and analytic epidemiological studies. Recorded variables were the following: patient's age, gender, the month of attack, and the location of the treating hospital. In the NHI system, Taiwan Island is divided into six districts: District 1 (the Taipei district), District 2 (the North district), District 3 (the Central district), District 4 (the South district), District 5 (the Kaohsiung district), and District 6 (the East district).

3. Results

A total of 4647 snakebite cases were reported in 2005−2009. There were 3340 (71.87%) episodes in the FH group, 893 (19.21%) in the FN group, 380 (8.10%) in the mixed group, and only 34 (0.73%) in the FA group. Most antivenom regimens used in the mixed group were the combination of FH and FN. The nationwide annual incidence of venomous snakebite was 40.49 per million persons (Table 1). The national annual incidence of the FH group was 29.10 per million persons, FN group was 7.78 per million persons, FA group was 0.30 per million persons, and mixed group was 3.31 per million persons. The geographic district incidences of snakebite are shown in Table 1 and Figure 1. District 1 had the highest case number. However, the incidence rate in District 1 was slightly less than the national incidence rate due to District 1 being the most densely populated area in the country. Although District 6 accounted for only one-sixth of the total cases, it had the highest incidence rate (about 7 times the national incidence rate). Regardless of the type of snakebite, District 6 had the highest incidence rate among all districts. District 3 had the lowest incidence of total snakebites but relatively high incidence rate in the FN group. FA group

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