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Causes and Predictive Factors Associated with "Diagnosis Changed" Outcomes in Patients Notified as Tuberculosis Cases in a Private Tertiary Hospital

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Background: The aim of our study was to evaluate the "diagnosis changed" rate in patients notified as tuberculosis (TB) on the Korean TB surveillance system (KTBS).
Methods: A total of 1,273 patients notified as TB cases on the KTBS in one private tertiary hospital in 2011 were enrolled in the present study. Patients were classified into three groups: "diagnosis maintained", "diagnosis changed" (initially notified as TB, but ultimately diagnosed as non-TB), and "administrative error" (notified as TB due to administrative errors).
Results: Excluding 17 patients in the "administrative error" group, the "diagnosis maintained" and "diagnosis changed" groups included 1,097 (87.3%) and 159 patients (12.7%), respectively. Common causes of "diagnosis changed" were nontuberculous mycobacterial (NTM) disease (51.7%, 61/118), and pneumonia (17.8%) in cases notified as pulmonary TB, and meningitis (19.5%, 8/41) and Crohn's disease (12.2%) in cases notified as extrapulmonary TB. Being older than 35 years of age (odds ratio [OR], 2.18) and a positive acid-fast bacilli stain (OR, 1.58) were positive predictors and a TB-related radiological finding (OR, 0.42) was a negative predictor for a "diagnosis changed" result via multivariate logistic regression analysis in pulmonary TB cases.
Conclusion: Because of a high "diagnosis changed" rate in TB notifications to the KTBS, the TB incidence rate measured by the KTBS may be overestimated. Considering the worldwide trend toward increased NTM disease, the "diagnosis changed" rate may increase over time. Thus, when reporting the annual TB notification rate in Korea, the exclusion of "diagnosis changed" cases is desirable.

Keywords: Nontuberculous Mycobacteria; Tuberculosis; Diagnostic Errors; Incidence

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Introduction

Tuberculosis (TB) is caused by the *Mycobacterium tuberculosis* complex, which was first discovered in 1882 by Robert Koch[1]. It usually affects the lungs (pulmonary TB), but can affect other sites as well (extrapulmonary TB). TB has been one of the most significant global pathogens in terms of human morbidity and mortality[2]. In 2010, there were 8.8 million incident cases of TB and 1.45 million deaths from TB worldwide[3]. Although the absolute number of cases and the incidence has decreased since 2002, TB still poses a huge health burden and is a major global health problem[3].

Although the prevalence of TB in Korea, based on chest radiography results, decreased from 5.1% in 1965 to 1.0% in 1995, 36,305 new TB patients were still registered on the Korean TB surveillance system (KTBS) in 2010, the highest incidence among all Organization for Economic Co-operation and Development (OECD) countries[4,5]. The Korean National Tuberculosis Association conducted seven nationwide TB prevalence surveys every 5 years from 1965 to 1995[6]. A web-based surveillance system, the KTBS which is based on doctor notifications, was launched in 2000 and has been implemented across the country to replace the nationwide survey[7]. In Korea, doctors are required to notify the KTBS of all cases of active TB immediately after diagnosis and treatment in accordance with Article 4 of the Infectious Disease Preventive Law (notification by physicians) and Article 20 of the Tuberculosis Preventive Law (notifying duty of healthcare facilities) of Korea[8].

KTBS data are used to analyze the burden of TB in Korea. Hence, the diagnostic accuracy of the KTBS data is important. Several previous studies have evaluated the accuracy of the TB surveillance system data. However, most of these reports have focused on the underestimation of TB incidence (due to the under-reporting of doctors) and emphasized the importance of notification[9-11]. There have also been some studies that have focused on the overestimation of TB burden[12,13]. These studies reported that notified TB cases were not always real TB patients. In accordance with this finding, sales of TB drugs are continuously decreasing in Korea (IMS PLUS, Korea, personal communication). To provide a more accurate measure of the incidence and characteristics of TB, "diagnosis changed" cases need to be excluded. The aim of our present study was to evaluate the diagnosis change rate, confounding diseases, and contributing factors to the notifications of TB cases to the KTBS at a single center (a private tertiary hospital).

Materials and Methods

A total of 1,273 patients notified from the Asan Medical Center in 2011 as TB cases on the KTBS were enrolled in this study. The electronic medical records and KTBS reporting data for these individuals were retrospectively analyzed.

1. Definition of TB cases

The definitions of terms used are in accordance with World Health Organization (WHO) guidelines[14]. "Pulmonary TB" was defined as a case of TB involving the lung parenchyma. "Extrapulmonary TB" was defined as a case of TB of an organ other than the lungs. Miliary TB or TB of unknown origin was categorized as pulmonary TB. Tuberculous intrathoracic lymphadenopathy or tuberculous pleural effusion without lung parenchymal lesions was classified as extrapulmonary TB. Patients with both pulmonary and extrapulmonary TB were classified as pulmonary TB.

In accordance with Korean national TB guidelines, treatment outcomes were classified into one of seven categories: cure, treatment completion, treatment failure, death, default, transfer out, and diagnosis changed. "Diagnosis changed" means that an initial TB diagnosis was presumably made and treatments were initiated accordingly, but that anti-TB therapies were later discontinued based on a determination that the diagnosis of TB was not correct. The meaning of "diagnosis changed" is similar to that of a misdiagnosis but with some differences. For example, in patients with life-threatening conditions, antibiotic regimens targeting multiple organisms, including *M. tuberculosis*, may be empirically prescribed. Even in this situation, the doctors should provide a notification that the case is TB immediately after prescribing anti-TB therapy, in accordance with Korean law. In our present study, the notified TB cases were classified into one of three possible groups; "diagnosis changed", "diagnosis maintained," or "administrative error." "Diagnosis maintained" indicates that anti-TB treatment was continued irrespective of the confirmation of TB. "Administrative error" means that the notification as TB was erroneous, such as, for example, when a latent TB infection was notified as an active TB case or when a single patient was notified as multiple TB cases.

2. Radiological findings

The radiological severity was classified into three grades (minimal, moderately advanced, and far advanced) based on the recommendations of the National Tuberculosis Association of the United Sates[15]. A pulmonary lesion revealed by chest radiography was categorized as "cavitary" or "noncavitary"; or as "unilateral" or "bilateral". We defined "TB-related radiological finding" as lesions of nodule(s), consolidation, or cavitation in the upper lung zones and internist reviewed radiologic findings using the radiologist's reading[16].

3. Statistical analysis

Age and body mass index (BMI) data were expressed as the

mean±the standard deviation. The clinical characteristics of the patient subjects were analyzed by an independent t-test and a chi-squared test. Risk factors were evaluated through a logistic regression model. p-values of <0.05 were considered significant. All analyses were performed with SPSS version 19 (SPSS Inc., Chicago, IL, USA).

4. Ethical considerations

This study was approved by the Institutional Review Board of the Asan Medical Center.

Results

Of the 1,273 patients enrolled in this study, 17 (1.3%) who were assigned to the "administrative error" group were excluded and a final cohort of 1,256 was included in the final analysis. Of these 1,256 patients, 130 (10.4%) were reported to have a treatment outcome of "diagnosis changed." After a review of medical records, an additional 29 patients (2.3%) were determined clinically to be "not TB" (nontuberculous mycobacterial [NTM] 7 patients, lung cancer 4 patients, Crohn's disease 2 patients, sarcoidosis 1 patient, Kikuchi disease 1 patient and others 14 patients). Consequently, the "diagnosis changed" group comprised 159 patients (12.7%), leaving 1,097 patients (87.3%) in the "diagnosis maintained" group (Figure 1).

The clinical characteristics of the notified TB patients are outlined in Table 1. The mean age at notification was 51.9±17.7 years in the "diagnosis maintained" group and 54.6±17.7 years in the "diagnosis changed" group. In these two groups, the BMI scores were 22.4±10.6 kg/m^2 and 22.3±3.7 kg/m^2, respectively. Smoking history, medication, and radiological findings did not differ between the groups. Malignancy was more frequent in the "diagnosis changed" group. The number of patients notified as pulmonary TB was 866 (68.9%), of whom 118 (13.6%) had a "diagnosis changed" outcome. Of the remaining 748 patients, 181 (24.2%) were acid-fast bacilli (AFB) smear-positive, 473 (63.2%) were *M. tuberculosis* culture positive, 229 (30.6%) were nucleic acid amplification (NAA) test positive, and 153 (20.5%) showed granulomas on histological examination. Patients with AFB smear-positive results have traditionally been considered to have TB. However, of the 217 patients with positive AFB smear and notified as pulmonary TB, only 83.4% had TB and others (15.7%) had NTM diseases in our study. The number of patients notified as extrapulmonary TB was 390 (31.1%), of whom 41 (10.5%) had a "diagnosis changed" outcome. Of the remaining 349 patients, 18 (5.2%) had AFB smear-positive results, 88 (25.2%) had *M. tuberculosis* culture positive results, 83 (23.8%) had positive NAA test results, and 176 (50.4%) showed granulomas on histological examination.

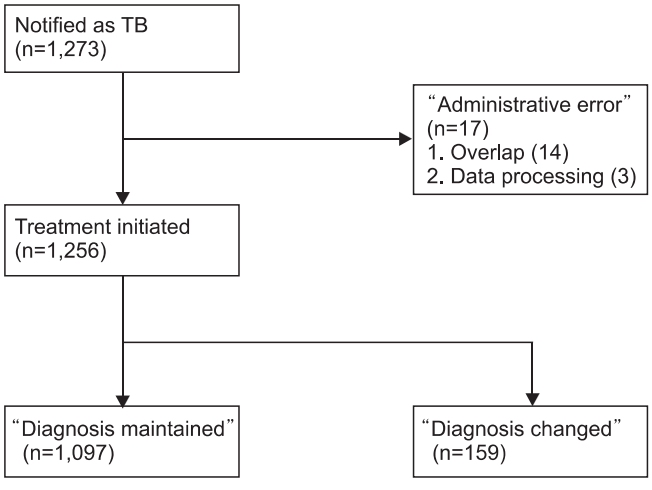

Figure 1. Flow chart of patient selection for this study. TB, tuberculosis.

The common causes of "diagnosis changed" are described in Table 2 and include NTM disease (51.7%, 61 out of 118 patients), pneumonia (17.8%, 21), lung cancer (13.6%, 16), and interstitial lung disease (5.1%, 6) in patients notified as pulmonary TB. Other lung diseases were healed TB (4 patients), benign lung nodules (3), IgG4-related disease (2), Behcet's disease (1), destructive bronchiolitis (1), sclerosing hemangioma (1), and hemoptysis of unknown causes (2). In 41 patients notified as extrapulmonary TB, the causes were bacterial or viral meningitis (19.5%, 8 patients), Crohn's disease (12.2%, 5), and complicated parapneumonic effusion (9.8%, 4). Other extrapulmonary diseases were Kikuchi disease (2 patients), bladder tumor (2), cystitis (2), encephalitis (2), sarcoidosis (2), NTM infection (2), Behcet's disease (1), cytomegalovirus colitis (CMV) colitis (1), CMV ventriculoencephalitis (1), central nervous system aspergillosis (1), epidural abscess (1), hematuria (1), healed TB (1), lymphoma (1), pericarditis (1), Q fever (1), seminoma (1), and tenosynovitis (1).

The predictive factors for a "diagnosis changed" outcome are presented in Table 3. Being older than 35 years (odds ratio [OR], 2.18; p=0.037) and having a positive AFB smear (OR, 1.58; p=0.047) were positive predictors for a "diagnosis changed" outcome. A TB-related radiological finding (OR, 0.42; p<0.001) was a negative predictor in multivariate logistic regression analysis in patients notified as pulmonary TB. In patients notified as extrapulmonary TB, only the absence of TB-related radiological finding (OR, 5.25; p<0.001) was a significant predictor for a "diagnosis changed" outcome.

Discussion

In the current TB notification system, both underestimation (due to under-reporting) and overestimation (due to "diagnosis change" cases) are possible, but in our study we could not estimate which one is bigger than the other. The most important

Table 1. Clinical characteristics of the 1,256 patients in the "diagnosis maintained" and "diagnosis changed" groups

Characteristic	Diagnosis maintained (n=1,097)	Diagnosis changed (n=159)	p-value
Age, yr	51.9±17.7	54.6±17.7	0.410
Male sex	630 (57.4)	97 (61.0)	0.393
BMI, kg/m^2	22.4±10.6	22.3±3.73	0.693
Ever smoker	468/1,031 (45.4)	70/154 (45.5)	0.989
Notified as pulmonary TB	748 (68.2)	118 (74.2)	0.125
Underlying disease			
Diabetes mellitus	151 (13.8)	30 (18.9)	0.087
HIV infection	3/724 (0.4)	1/111 (0.9)	0.489
Malignancy	210 (19.1)	42 (26.4)	0.032
Chronic renal disease	58 (5.3)	7 (4.4)	0.638
Medication			
Immunosuppressive agents	33 (3.0)	6 (3.8)	0.603
Steroids	85 (7.7)	13 (8.2)	0.851
Radiological findings, lung			
Cavitary disease	135 (18.0)	20 (16.9)	0.772
Far advanced disease	159 (21.3)	22 (18.6)	0.517
Unilateral	522 (69.8)	80 (67.8)	0.663
TB-related findings			
Positive sputum AFB stain	181 (24.2)	36 (30.5)	0.099
Positive for *Mycobacterium tuberculosis* culture of sputum	473 (63.2)	0 (0.0)	<0.001
Positive NAA	229 (30.6)	0 (0.0)	<0.001
Granulomas on histology	153 (20.5)	14 (11.9)	0.001
Notified as extrapulmonary TB	349 (31.8)	41 (25.8)	0.125
TB-related findings			
Positive specimen AFB stain other than sputum	18 (5.2)	0 (0.0)	0.109
Positive for *M. tuberculosis culture* of other than sputum	88 (25.2)	0 (0.0)	<0.001
Positive NAA	83 (23.8)	0 (0.0)	<0.001
Granulomas on histology	176 (50.4)	2 (4.9)	<0.001

Values are numbers (%) or the mean±SD.
BMI: body mass index; TB: tuberculosis; HIV: human immunodeficiency virus; AFB: acid-fast bacilli; NAA: nucleic acid amplification.

result of our study is that more than 10% of patients notified as TB cases did not in fact have TB. Given that the estimated incidence of TB in Korea is made using the annual notification rate, this incidence may well be an overestimate.

From 1965 to 1995, the prevalence of TB in Korea was estimated through a nationwide representative sampling survey every 5 years. As this prevalence has decreased, the TB burden has been followed since 2000 using the KTBS notification system. However, TB notifications have been considered more likely to be an underestimate of the true incidence of this disease because of a lack of voluntary reporting by doctors[17,18]. On the other hand, because TB is still prevalent in Korea, many doctors diagnose it on the basis of a single chest radiograph alone, without bacteriological confirmation. In addition, many doctors commence anti-TB medication without receiving a confirmation of TB. According to Korean Infectious Disease Preventive Law, doctors should notify the KTBS of any new cases as soon as anti-TB medication is prescribed, irrespective of any bacteriological confirmation. This procedure may result in an overestimation of TB notification. In our present study, about 12.5% of the patients from our hospital notified as TB cases (13.6% in pulmonary TB and 10.5% in extrapulmonary TB) later became "diagnosis changed". Although 29 patients were not notified as "diagnosis changed," these

Table 2. Common causes of a "diagnosis changed" outcome

Pulmonary	n=118	Extrapulmonary	n=41
NTM infection	61 (51.7)	Meningitis	8 (19.5)
Pneumonia	21 (17.8)	Crohn's disease	5 (12.2)
Lung cancer	16 (13.6)	Complicated pleural effusion	4 (9.8)
Interstitial lung disease	6 (5.1)	Other diseases	24 (58.5)
Other lung diseases	14 (11.9)		

Values are presented as numbers (%).
NTM: nontuberculous mycobacteria.

Table 3. Predictive factors of a "diagnosis changed" outcome in patients notified as pulmonary tuberculosis cases

Variable	No. (%)	Univariate analysis*		Multivariate analysis*	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Age≥35 yr	713/866 (82.3)	2.55 (1.30–5.00)	0.01	2.18 (1.05–4.52)	0.037
Male	543/866 (62.7)	0.92 (0.62–1.37)	0.68	-	-
BMI>18.5 kg/m^2	733/855 (85.7)	1.25 (0.69–2.26)	0.47	-	-
Ever smoking	424/845 (50.2)	0.90 (0.61–1.33)	0.59	-	-
Positive sputum AFB stain	217/818 (26.5)	1.44 (0.45–1.07)	0.09	1.58 (1.01–2.47)	0.047
TB-related radiological finding	706/864 (81.7)	0.42 (0.27–0.65)	<0.001	0.42 (0.26–0.68)	<0.001
Diabetes mellitus	144/866 (16.6)	1.51 (0.94–2.43)	0.09	1.14 (0.67–1.92)	0.636
HIV seropositivity	3/540 (0.6)	2.99 (0.26–33.34)	0.37	-	-
Malignancy	195/866 (22.5)	1.48 (0.96–2.28)	0.08	1.33 (0.84–2.12)	0.225
Chronic renal disease	43/866 (5.0)	0.8 (0.32–2.15)	0.70	-	-
Immunosuppressive agents	27/866 (3.1)	1.46 (0.54–3.93)	0.45	-	-
Steroids	71/866 (8.2)	1.18 (0.60–2.31)	0.63	-	-

*Statistical comparisons of the data were performed using logistic regression analysis.
OR: odds ratio; CI: confidence interval; BMI: body mass index; AFB: acid-fast bacilli; TB: tuberculosis; HIV: human immunodeficiency virus.

29 patients should have been notified as "diagnosis changed" case at that time. Hence, we enrolled these 29 patients as "diagnosis changed" cases. If we excluded these 29 patients from "diagnosis changed" case, "diagnosis changed" rate would be 10.4% (130/1,256) in patients notified as TB. We suggest that "diagnosis changed" TB cases should be excluded when reporting the annual TB notification rate in Korea.

In patients notified as pulmonary TB cases on the database, predictive factors for a "diagnosis changed" outcome were found to be an age older than 35 years and a positive AFB smear at diagnosis. The most common cause of "diagnosis change" was found to be NTM pulmonary infection. The chance of developing NTM disease increases with age in AFB smear-positive patients[19]. In Korea, patients with AFB smear-positive specimens have traditionally been considered to have TB, and anti-TB treatment is promptly administered in these cases[20]. We should recognize that more than 15% of sputum AFB smear-positive patients notified as pulmonary TB did not have TB but had NTM disease in our study. Considering the trend towards increased levels of NTM disease, it is expected that the mistaken notification of NTM disease as TB will increase. Hence, it is important to be able to rapidly distinguish between *M. tuberculosis* and NTM by conducting an NAA test in AFB-positive specimens. We contend that this recommendation should be incorporated into current Korean TB guidelines.

In our present analyses, the proportion of extrapulmonary TB (31.1%) was relatively high compared with that found in a previous study[5]. This may be due to the inherent characteristics of a given tertiary care hospital. Because the diagnosis of extrapulmonary TB is more difficult than that of pulmonary TB, more patients with suspected extrapulmonary TB tend to visit tertiary care hospitals. Due to the diagnostic difficulty associated with extrapulmonary TB, we expected that the "diagnosis changed" rate would be higher for extrapulmonary TB than pulmonary TB. However, in reality the "diagnosis changed" rate was slightly, though not significantly, higher for pulmonary TB (13.6% vs. 10.5%, respectively). This result may be due to the finding that the exclusion of TB diagnosis is

more difficult in instances of extrapulmonary TB than in pulmonary TB.

This study has several limitations to note. First, due to the retrospective nature of our study and the fact that it involves data from a single tertiary care center, it is more difficult to generalize and apply the results to other hospitals in Korea. However, an overestimation of TB is highly probable in small-scale hospitals because of a lower rate of bacteriological confirmation for TB diagnosis[21]. Second, because we only analyzed patients notified as TB cases, other TB patients who were not notified as TB may have been overlooked in our analysis, leading to an underestimation of the TB burden. Third, a high proportion of TB patients (278 patients, 25.3%) were clinically diagnosed and the accuracy of the TB diagnosis could not be confirmed in these cases. However, this is a common challenge with TB diagnoses. Finally, due to the increased NTM infection trend found in this study, as well as more widely in Korea, an ironic situation has developed whereby a positive sputum AFB stain, which is also used to diagnose NTM, has become a significant predictive factor for a "diagnosis changed" outcome in patients notified as pulmonary TB cases. However, this would not be the situation in countries where the NTM infection rate is low.

In conclusion, TB notifications may be an overestimate of the true incidence of this disease in Korea, particularly because of the increased frequency of NTM infections. Therefore, in order to estimate, more accurately, the incidence of TB in Korea, it would be desirable in the future to exclude patients with a "diagnosis changed" outcome from the total number of patients notified as TB.

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