



CT findings in apical versus basal involvement of pulmonary tuberculosis

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PURPOSE

We aimed to compare clinical features and computed tomography (CT) findings of pulmonary tuberculosis (TB) in lower lobe basal segments and upper lobe apical or apicoposterior segments.

MATERIALS AND METHODS

We retrospectively reviewed medical records and chest CT scans of 986 adults who were diagnosed with active pulmonary TB. Active pulmonary TB confined to the basal segments was found in 21 patients. Sixty patients had disease localized to the apical or apicoposterior segments only. Clinical features and CT abnormalities of the lung parenchyma, airways, mediastinal and hilar lymph nodes, and pleura were compared between these two groups.

RESULTS

A significant difference was observed between two groups in terms of underlying disease prevalence associated with an immunocompromised state (basal, 6/21, 28.6%; apical or apicoposterior, 3/60, 5%; $P = 0.008$). Chest CT findings, including consolidation ($P = 0.0016$), lymphadenopathy ($P = 0.0297$), and pleural effusion ($P = 0.008$), were more common in basal segment TB than in apical or apicoposterior segment TB. Small nodules were less common in basal segment TB than in apical or apicoposterior segment TB ($P = 0.0299$). The tree-in-bud sign was the most common CT finding in both basal segment TB (17/21, 81%) and apical or apicoposterior segment TB groups (53/60, 88.3%) ($P = 0.4633$).

CONCLUSION

Lower lobe basal segment TB was more commonly present with common CT findings of primary pulmonary TB including consolidation, mediastinal and hilar lymphadenopathy, and pleural effusion than apical or apicoposterior segment TB.

Tuberculosis (TB) is a common infection worldwide and remains an important cause of morbidity and mortality, particularly in developing countries (1). In 2010, 8.8 million people developed overt disease; approximately 1.1 million deaths occurred among human immunodeficiency virus (HIV)-negative people and 0.35 million deaths occurred among HIV-positive people (2).

Several host factors may contribute to radiologic manifestations of pulmonary TB, including prior exposure to TB, age, and underlying immune status (3). Radiologic manifestation of pulmonary TB has been divided into primary and postprimary TB, each with a characteristic radiologic pattern. Primary TB occurs most commonly in children without prior exposure to TB and without acquired specific immunity. Primary TB commonly presents as hilar or mediastinal lymphadenopathy, airspace consolidation, or pleural effusion. Postprimary TB is considered to be a reactivation of a previous TB lesion. Radiographically, postprimary TB usually presents as focal or patchy heterogeneous consolidation involving the apical and posterior segments of the upper lobes and less frequently in the superior segments of the lower lobes. On computed tomography (CT) scans, the most common findings of postprimary TB are centrilobular small nodules, branching linear and nodular opacities (tree-in-bud sign), patchy or lobular areas of consolidation, and cavitation (1, 3–6).

Isolated involvement of basal segments of the lower lobes in pulmonary TB cases is unusual, and often causes great confusion in the diagnosis of pulmonary TB (3, 7). Because early diagnosis of pulmonary TB plays an important role in the treatment of TB, proper understanding of atypical radiologic manifestation is critical (8, 9).

To the best of our knowledge, the CT findings of pulmonary TB involving basal segments have not been widely investigated. The present study compared clinical features and CT findings of pulmonary TB in basal segments and apical or apicoposterior segments, and assessed the frequent radiologic findings of TB in basal segments.

Materials and methods

Patients

Approval of the hospital ethics committee was obtained for this study. We retrospectively reviewed chest CT scans of 986 consecutive adults who were diagnosed with active pulmonary TB at our institution, an 814-bed urban community-based university teaching hospital, from March 2005 to February 2011. Patients were included in the study if they had a positive culture or staining for *Mycobacterium tuberculosis* from a sputum specimen, bronchial washing, or lung biopsy. Disease confined to the basal segments of the lower lobes, segments 7, 8, 9, and 10 of the right lower lobe and segments 7+8, 9, and 10 of the left lower lobe, was found in 21 patients. We excluded pulmonary TB cases involving

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segments 3, 4, 5, and 6. Coincident involvement cases, such as basal segment plus any other segment and apical (or apicoposterior) segment with any other segment, were also not included in this study. We also excluded seven cases of coincident involvement of apical (or apicoposterior) and basal segments. We identified 60 patients who had TB lesions localized only to the apical or apicoposterior segments of the upper lobes, segment 1 of the right upper lobe and segment 1+2 of the left upper lobe. No patient was positive for HIV. Case histories were reviewed to ascertain the frequency of coexistent medical conditions associated with an immunocompromised state, such as diabetes mellitus type 1 and 2, chronic renal failure, drug and alcohol abuse, malnutrition, corticosteroid or other immunosuppressive therapy, and concurrent or recent malignant neoplasms.

Imaging technique

CT scans were obtained using a 16-slice multidetector CT scanner (MX IDT 8000 IDT, Philips Medical Systems, Haifa, Israel) or a 64-slice multidetector CT scanner (Brilliance 64, Philips Medical Systems). These CT images were obtained from the apices to costophrenic angles.

Chest CT scans were obtained in 13 patients of the basal segment TB group and in 34 patients of the apical or apicoposterior TB group. Imaging parameters for the 16-slice multidetector CT scanner were as follows: 120 kV and 200 mAs, with 0.75 s rotation time and 16×1.5 mm collimation. Imaging parameters for the 64-slice multidetector CT scanner were as follows: 120 kV and 250 mAs, with 0.75 s rotation time and 64×1.5 mm collimation. Intravenous administration of an average volume of 90 mL or 1.4 mL/kg of nonionic contrast material (Ultravist 300, Bayer Schering Pharma AG, Berlin, Germany, or Omnipaque 300; GE Healthcare, Carrigtohill, Ireland) containing 300 mg/mL iodine was performed. The contrast material was administered intravenously using a power injector at a rate of 3 mL/s for the contrast-enhanced study.

High-resolution CT scans with an edge-enhancing algorithm were obtained in eight patients of the basal segment TB group and in 26 patients of the apical or apicoposterior TB group. Imaging parameters for the 16-slice

multidetector CT scanner were as follows: 140 kV and 200 mA, with 0.75 s rotation time and 16×0.75 mm collimation. Imaging parameters for the 64-slice multidetector CT scanner were as follows: 120 kV and 250 mA, with 0.5 s rotation time and 40×0.625 mm collimation. All examinations were performed with the patient in the supine position with breath-hold during inspiration without administration of contrast material. Images were obtained with both mediastinal (width, 350–450 HU; level, 20–40 HU) and lung (width, 1200–1600 HU; level, -500 to -700 HU) window settings.

Image analysis

CT scan data were available on a picture archiving and communication system (PACS, Infinitt Healthcare Co. Ltd., Seoul, Republic of Korea), and all images were retrospectively reviewed at a PACS monitor.

Three radiologists (a chest radiologist with 14 years of experience and two fourth-year residents) reviewed the images independently and diagnostic conclusions were reached by consensus. The CT images were assessed for the location, consolidation, ground-glass opacity, cavity, atelectasis, nodule, mass, mediastinal and hilar lymphadenopathy, and pleural effusion. Consolidation was defined as homogeneous opacification of the parenchyma with obscuration of the underlying vessels. The ground-glass opacity was defined as a hazy area of increased opacity or attenuation without obscuration of the underlying vessels. In addition, the presence of endobronchial lesion, tree-in-bud lesion, interstitial thickening, pneumothorax, and pneumomediastinum was recorded. Mediastinal and axillary lymphadenopathy was

defined as the presence of one or more lymph nodes with a short-axis diameter larger than 10 mm.

Statistical analysis

Statistical analysis was performed using the SAS software package (Statistical Analysis System, version 9.1, SAS Institute, Cary, North Carolina, USA). The mean age of the patients who had basal segment TB and mean age of those who had apical or apicoposterior segment TB were tested using Welch's two-sample t test. The frequency of each CT abnormality was compared between the basal segment TB group and the apical or apicoposterior TB group using Fisher's exact test. A *P* value of less than 0.05 was deemed to indicate a statistically significant difference.

Results

Disease confined to the basal segments of the lower lobes, segments 7, 8, 9, and 10 of the right lower lobe (n=10), segments 7+8, 9, and 10 of the left lower lobe (n=8), and both sides (n=3), was found in 21 patients. This basal segment TB study group included nine males and 12 females; the mean age was 43.8 years, with a range of 23 to 82 years. In 60 patients, TB lesions were localized to the apical or apicoposterior segments of the upper lobes, segment 1 of the right upper lobe (n=30), segment 1+2 of the left upper lobe (n=19), and both sides (n=11). This apical or apicoposterior segment TB study group included 49 males and 11 females; the mean age was 38.6 years, with a range of 22 to 82 years. The demographics of patients with pulmonary TB in basal segment and apical or apicoposterior segment TB groups are summarized in Table 1.

Table 1. Demographics of patients with pulmonary tuberculosis in lower lobe basal segment and upper lobe apical or apicoposterior segment

	Localization of pulmonary tuberculosis		<i>P</i> ^a
	Basal (n=21)	Apical or apicoposterior (n=60)	
Age (years), mean±SD	43.8±18.4	38.6±12.6	0.2407
Gender, n (%)	Female	12 (57.1)	0.0015
	Male	9 (42.9)	
Underlying disease, n (%)	6 (28.6)	3 (5)	0.008

^aCalculated between lower lobe basal and upper lobe apical or apicoposterior tuberculosis groups by Welch's two-sample t test and Fisher's exact test.

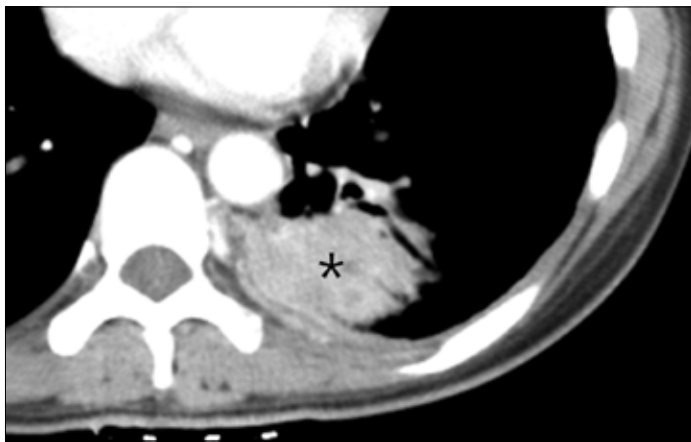


Figure 1. Active pulmonary tuberculosis in a 34-year-old woman. Axial contrast-enhanced CT image at the mediastinal window setting shows consolidation (asterisk) in the left lower lobe posterior basal segment.

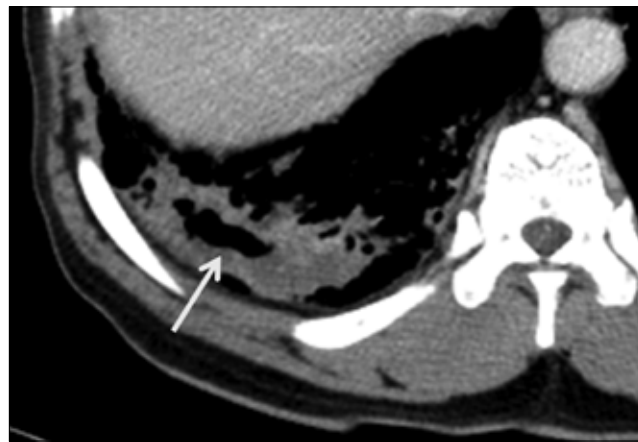


Figure 2. Active pulmonary tuberculosis in a 64-year-old man with underlying advanced gastric cancer. Axial contrast-enhanced CT image at the mediastinal window setting shows consolidation with internal cavity (arrow) in the right lower lobe posterior and lateral basal segments.

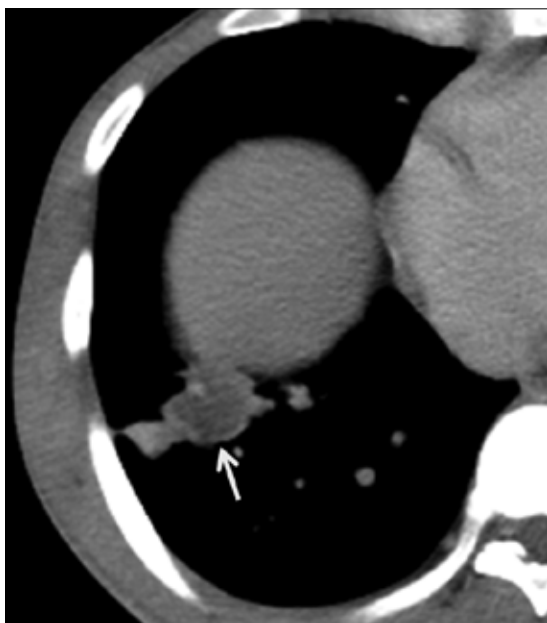


Figure 3. Active pulmonary tuberculosis in a 31-year-old man with underlying chronic myeloid leukemia. Axial contrast-enhanced CT image at the mediastinal window setting shows a consolidation with necrosis (arrow) in the right lower lobe lateral basal segment.

In the basal segment TB group, underlying diseases associated with an immunocompromised state were observed in six patients (6/21, 28.6%); these diseases included ankylosing spondylitis, stomach cancer, colon cancer, chronic myeloid leukemia, and type 2 diabetes mellitus. In the apical or apicoposterior segment TB group, three patients (3/60, 5%) were found with underlying diseases, including bladder cancer, amyotrophic lateral sclerosis, and diabetes mellitus ($P = 0.008$).

A gender difference was found between the two groups. Basal segment TB occurred more frequently in female patients than in male patients, whereas

apical or apicoposterior segment TB occurred more frequently in male patients ($P = 0.0015$).

Consolidation (Figs. 1–3) was more frequent in the basal segment TB group (15/21, 71.4%) than in the apical or apicoposterior segment TB group (18/60, 30%) ($P = 0.0016$). The prevalence of pleural effusion also differed significantly between the two groups, affecting six of 21 patients (28.6%) in the basal segment TB group and three of 60 (5%) in the apical or apicoposterior segment TB group ($P = 0.008$). Lymphadenopathy was more frequent in the basal segment TB group (6/21, 28.6%) than in the apical or apicoposterior segment TB group (5/60, 8.3%)

($P = 0.0297$). Small nodules (Fig. 4) were less common in the basal segment TB group (10/21, 47.6%) than in the apical or apicoposterior segment TB group (45/60, 75%) ($P = 0.0299$). Although no statistically significant difference was observed, a tendency toward a higher prevalence of mass (Fig. 5) in the basal segment TB group was also noted (basal segment, 4/21, 19%; apical or apicoposterior segment, 3/60, 5%) ($P = 0.0702$).

No statistically significant difference was found between the basal segment and apical or apicoposterior TB groups with respect to the mean age of the patients, prevalence of ground-glass opacity, interstitial thickening, tree-in-bud sign, cavity, atelectasis, mass, large nodule, endobronchial involvement, or bronchiectasis. The tree-in-bud sign was the most common CT finding in both the basal segment TB (17/21, 81%) and apical or apicoposterior segment TB groups (53/60, 88.3%) ($P = 0.4633$). CT findings of pulmonary TB in basal segments and apical or apicoposterior segments are summarized in Table 2.

Discussion

Traditionally, the clinical, pathological, and radiological manifestations of reactivated TB were considered to be quite distinct from those of primary TB. This concept, however, has been recently challenged. Recent studies based on DNA fingerprinting have suggested that chest radiographic features are similar between patients who apparently have primary TB and those

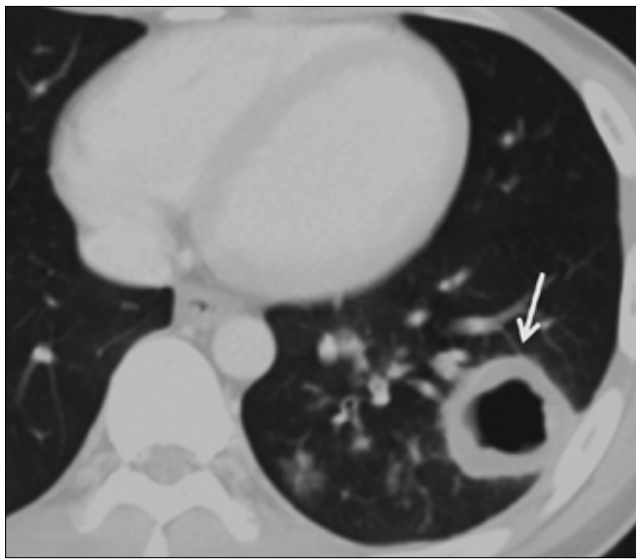


Figure 4. Active pulmonary tuberculosis in a 26-year-old man. Axial contrast-enhanced CT image at the lung window setting shows a thick-wall cavity (*arrow*), consolidation, and small nodules in the left lower lobe lateral basal segment.



Figure 5. Active pulmonary tuberculosis in a 45-year-old man with underlying diabetes mellitus. Axial contrast-enhanced CT image at the mediastinal window setting shows a poorly enhancing mass (*asterisk*) with an internal calcification and peripheral consolidation in the right lower lobe medial and posterior basal segments.

who have reactivated TB. The previously mentioned differences in chest radiographic findings between children and adults with pulmonary TB may then reflect differential efficacy

of the immune response, rather than differences in the timing of infection. Neonates, young children, or HIV-infected persons who have impaired cell-mediated immune responses tend

to have atypical manifestation of TB, whereas immunocompetent patients tend to have typical manifestation of previously known reactivated TB. Thus, the only independent predictor of radiographic appearance may be integrity of the host immune response (8, 9).

In the present study, the relatively frequent CT findings of lower lobe basal segment TB compared to upper lobe apical or apicoposterior TB were consolidation, mediastinal and hilar lymphadenopathy, and pleural effusion, which were previously thought to be typical radiological findings of primary pulmonary TB by recent infection.

Consolidation is the most frequent characteristic of basal segment TB with statistical significance (15/21, 71.4%). Because TB manifesting as consolidation may often be indistinguishable from bacterial pneumonia, the diagnosis at a hospital might be delayed (10, 11). In previous studies, TB in the lower lung fields in adults is a frequent characteristic of tuberculous pneumonia, which is manifested as homogeneous segmental or lobar consolidation on a chest radiograph (10, 12). On CT, TB lesions might show necrotic or cavitary consolidation, bronchial or bronchiolar lesions including branching opacities, and mass (1, 13). These findings could be helpful for differential diagnosis of TB from bacterial pneumonia.

Table 2. Comparison of CT findings of tuberculosis involving lower lobe basal segment and upper lobe apical or apicoposterior segment

CT findings, n (%)	Localization of pulmonary tuberculosis		P ^a
	Basal (n=21)	Apical or apicoposterior (n=60)	
Consolidation	15 (71.4)	18 (30)	0.0016
Ground glass opacity	3 (14.3)	2 (3.3)	0.1067
Tree-in-bud sign	17 (81)	53 (88.3)	0.4633
Cavity	7 (33.3)	28 (46.7)	0.3186
Atelectasis	1 (4.8)	0 (0)	0.2593
Mass	4 (19)	3 (5)	0.0702
Large nodule	3 (14.3)	11 (18.3)	1.000
Small nodule	10 (47.6)	45 (75)	0.0299
Interstitial thickening	1 (4.8)	0 (0)	0.2593
Endobronchial involvement	0 (0)	1 (1.7)	1.000
Bronchiectasis	3 (14.3)	3 (5)	0.1768
Lymphadenopathy	6 (28.6)	5 (8.3)	0.0297
Pleural effusion	6 (28.6)	3 (5)	0.0080

^aCalculated between lower lobe basal and upper lobe apical or apicoposterior tuberculosis groups by Fisher's exact test.

Contrast-enhanced CT has the potential advantage to detect the necrotic lung consolidation in TB patients. It is also useful in the detection of combined vascular abnormality including dilated bronchial arteries, intercostal arteries or other cardiac, pericardiac abnormality, as well as in guiding biopsy. Identification of dilated bronchial or intercostal arteries on contrast-enhanced CT is important for percutaneous arterial embolization in TB patients with hemoptysis.

Mediastinal and hilar TB lymphadenopathy is uncommon in adults, and was previously considered to be a feature of only primary or first infection with *M. tuberculosis* (1, 14). In the present study, the patients with basal segment TB tended to have mediastinal and hilar lymphadenopathy compared to the patients with apical or apicoposterior segment TB. Contrast-enhanced CT is useful for the identification of necrotic lymph node, which is relatively common in TB lymphadenopathy.

Pleural effusion was observed more frequently in the basal segment TB group than in the apical or apicoposterior segment TB group. Pleural effusion occurs in approximately 5% of patients with *M. tuberculosis* infection. Tuberculous pleural effusions can manifest as primary or reactivated disease (15).

Generally, the most common CT findings of postprimary TB are centrilobular small nodules as well as branching linear and nodular opacities (tree-in-bud sign) (1). In the present study, the tree-in-bud sign was the most common CT finding in both the basal segment TB (81%) and apical or apicoposterior segment TB groups (88.3%) ($P = 0.4633$). No statistically significant differences were noted between the two groups, although small nodules were uncommon in the basal segment TB group (47.6%) compared to the apical or apicoposterior segment TB group (75%) ($P = 0.0299$). However, small nodules were also frequently observed in the basal segment TB group. Many patients with basal segment TB presented with typical CT findings of postprimary TB. However, postprimary TB findings were observed less frequently in the basal segment TB group than in the apical or apicoposterior segment TB group.

Compared to patients with apical or apicoposterior segment TB, those with

basal segment TB had a higher prevalence of an immunocompromised state, including ankylosing spondylitis, stomach cancer, colon cancer, chronic myeloid leukemia, and diabetes mellitus. Unusual or atypical manifestations of pulmonary TB are common in patients with impaired host immunity. Pulmonary TB in diabetic, elderly, or immunocompromised patients has often been suggested to have an atypical pattern and distribution (4, 12, 16–18). This has been confirmed, particularly in patients with acquired immune deficiency syndrome (AIDS) (19, 20). These unusual manifestations are now thought to be manifestations of primary TB (21).

Lower lung field TB is more common in older than in younger patients, as elderly people have more impaired T-lymphocyte function than young people (22–24). In the present study, however, no statistically significant difference was observed in the mean patient age between the basal segment and apical or apicoposterior TB groups. This result might be influenced by underlying disease associated with immunologic state rather than an aging effect. Previous studies have emphasized the predominance of lower lung field TB in women, and although no reliable explanation was found for the higher incidence of disease in women, the results of the present study are consistent with previous reports. Moreover, some studies reported that women may have higher rates of progression from infection to disease and higher case fatality in their early reproductive ages (25–29).

Our radiological findings concur with those of Koh et al. (30). In their study, the most common radiographic findings in primary pulmonary TB by recent infection in previously healthy adolescents were upper lung lesions that were thought to be radiographic findings of reactivated pulmonary TB by remote infection.

To the best of our knowledge, the present study is the first to have described CT findings of basal segment TB and evaluated its association with host immune status. Several reports exist regarding atypical or unusual manifestations of adult TB on radiographs, particularly focusing on lower lobe predominance (12, 24, 31–33). Compared to radiographs, CT scans provide more

precise information on the extent and distribution of disease (34).

The present study has some limitations, including its retrospective nature, which did not allow uniform CT protocols to be implemented in all cases. In addition, we did not use the serial tuberculin skin test or DNA fingerprinting test that confirms the strain of *M. tuberculosis* to demonstrate recent or remote infection and determine primary TB or postprimary TB (8). In some cases, Bacillus Calmette-Guérin (BCG) vaccination in the neonatal period may affect the host immune response and radiologic manifestation of TB infection. In addition, the present study suffers from verification bias, which occurs when a study population includes only patients with a verified disease status. Only patients with bacteriologically proven TB were included from the population of patients from 2005 to 2011. This bias could have affected the results of the study. Finally, interobserver variation was not evaluated. Further studies to assess different CT findings between immunocompetent and immunocompromised groups of TB patients are necessary with larger cases.

In conclusion, basal segment TB had typical CT findings of both primary and postprimary TB. However, postprimary TB findings such as small nodules were less common in the basal segment TB group than in the apical or apicoposterior segment TB group. Basal segment TB was more commonly present with other CT findings, including consolidation, mediastinal and hilar lymphadenopathy, and pleural effusion, which were previously thought to be typical radiological findings of primary pulmonary TB by recent infection than apical or apicoposterior segment TB. If these abnormal findings are present on CT, the possibility of TB might be considered in the case of basal lung lesion.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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