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Radiological Differentiation of Multi-Drug Resistant and Drug-Sensitive Tuberculosis Using Chest X-Rays

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ABSTRACT

Background: Tuberculosis continues to pose a significant global health challenge, with increasing incidence of multidrug-resistant TB (MDR-TB). Radiological features have the potential to distinguish MDR-TB from drug-sensitive TB (DS-TB). Early radiographic identification facilitates timely diagnosis and treatment, particularly in resource-limited settings.

Objective: To compare chest X-ray findings between cases of multidrug-resistant TB (MDR-TB) and drug-sensitive TB (DS-TB).

Methodology: This retrospective comparative study included 240 pulmonary TB patients (120 with MDR-TB and 120 with DS-TB). Chest X-rays were assessed for lesion size, cavitation, consolidation, and non-parenchymal changes. Findings were compared between groups based on lung zones and cavity characteristics. Data analysis was performed using SPSS, with $p < 0.05$ considered statistically significant.

Results: Patients with MDR-TB exhibited a higher prevalence of large lesions (93.3%) and multiple cavities (68.3%). Consolidation and fibrosis were more frequently observed in MDR-TB, whereas infiltrates were predominant in DS-TB. The upper lung zones were primarily affected in MDR-TB, often with extensive bilateral involvement. Non-parenchymal features such as pleural thickening and tracheal deviation occurred more frequently in MDR-TB.

Conclusion: Chest X-rays demonstrate distinct radiographic patterns in MDR-TB compared to DS-TB. The presence of large lesions, multiple cavitations, and chronic fibrotic changes is suggestive of drug resistance. Recognition of these radiological differences can facilitate early suspicion of MDR-TB. Radiographic assessment continues to be a valuable tool for TB evaluation, particularly in low-resource settings.

Keywords: Radiological Findings; MDR-TB; Drug-Sensitive Tuberculosis

Introduction

Tuberculosis (TB) remains a major infectious disease worldwide and continues to pose a substantial threat to public health, particularly in low- and middle-income countries. The World Health Organization (WHO) reports that millions of new TB cases are diagnosed each year, and TB remains among the top ten causes of death globally [1]. Mycobacterium tuberculosis, the causative agent, primarily affects the lungs but can involve nearly any organ system. Despite the availability of effective anti-tubercular therapies, the emergence and increasing prevalence of drug-resistant TB, particularly multidrug-resistant TB (MDR-TB), present significant challenges to TB control efforts [2]. MDR-TB, defined as resistance to the two most potent first-line anti-TB drugs, isoniazid and rifampin, necessitates longer, more toxic, and less effective treatment regimens. The increasing incidence of MDR-TB complicates clinical management and results in greater morbidity, mortality, and economic burden on healthcare systems [3,4].

Accurate and timely differentiation between drug-sensitive TB (DS-TB) and MDR-TB is critical for effective patient management and public health interventions. Conventional microbiological methods, such as sputum culture and drug susceptibility testing, remain the gold standard for distinguishing MDR-TB from DS-TB. However, these techniques are resource-intensive, time-consuming, and frequently unavailable in high-burden settings [5]. Although rapid molecular assays exist, their implementation is often limited by cost and infrastructure constraints. Consequently, clinicians often rely on clinical, epidemiological, and radiological indicators to guide initial management. Chest X-ray (CXR) is one of the most accessible and widely used diagnostic tools for TB assessment, providing rapid evaluation of pulmonary involvement and disease severity [6]. Certain radiographic patterns, including multiple cavities, bilateral disease, extensive parenchymal involvement, and pleural thickening, have been reported to occur more frequently in MDR-TB than in DS-TB [7,8]. However, the specificity and reliability of these features for predicting drug resistance remain unproven and inconsistent across populations and study designs. Additionally, the radiological appearances of MDR-TB and DS-TB often overlap, complicating differentiation and underscoring the need for further research [9].

To address these challenges, this study systematically compares chest X-ray findings in cases of multidrug-resistant TB and drug-sensitive TB. The primary objective is to improve MDR-TB versus DS-TB diagnosis by identifying radiological features that may facilitate differentiation, particularly in resource-limited settings where rapid molecular diagnostics are not consistently available. Early identification of MDR-TB enables timely treatment initiation, reduces transmission, and improves patient outcomes. Additionally, characterizing the radiological spectrum of MDR-TB and DS-TB may provide insights into disease pathogenesis and progression. Although the literature on this topic is expanding, most previous studies have been limited by small sample sizes, retrospective designs, or a lack of standardized radiographic assessment. This study addresses these limitations by using a rigorous comparative methodology and uniform radiological assessment criteria. The findings are expected to inform clinical decision-making and public health policy, thereby contributing to more effective TB control. This research addresses a critical knowledge gap and helps clinicians differentiate MDR-TB from DS-TB using an accessible imaging modality.

Objective

To compare chest X-ray findings between cases of multidrug-resistant TB (MDR-TB) and drug-sensitive TB (DS-TB).

Methodology

A retrospective, comparative cross-sectional study was conducted in the Department of Pharmacology at Bacha Khan Medical College, in collaboration with the Department of Medicine at Mardan Medical Complex, from January 2022 to March 2025. The study included 240 adult subjects: 120 with Multidrug Resistant Tuberculosis (MDR-TB) and 120 with Drug-Sensitive Tuberculosis (DS-TB). MDR-TB is defined as tuberculosis resistant to at least isoniazid and rifampicin, confirmed through genotypic or phenotypic drug susceptibility testing. DS-TB is defined as pulmonary tuberculosis sensitive to first-line antitubercular drugs. Eligible participants were adults aged 18 years or older, diagnosed with pulmonary tuberculosis using sputum smear microscopy, GeneXpert MTB/RIF, culture, or drug susceptibility testing (DST). All participants underwent a baseline posterior-anterior (PA) chest X-ray prior to treatment initiation.

All chest X-rays were performed using a standardized posterior-anterior projection and independently analyzed by two experienced radiologists blinded to the patients' drug-resistance status to minimize bias. Discrepancies in interpretation were resolved by consensus. Radiological assessment included determination of lesion size (small <2 cm, medium 2–4 cm, large >4 cm), number, and localization, as well as the presence of consolidation, infiltrates, cavities, bronchiectasis, nodules, fibrosis, and pleural involvement. Cavities were further classified by number (solitary or multiple) and size (≤4 cm or >4 cm).

Additional non-parenchymal manifestations, including pleural effusion (unilateral or bilateral), pleural thickening, hilar uplift, and tracheal deviation, were also evaluated.

The presence and laterality of these findings were documented. The distribution of these manifestations was compared between the MDR-TB and DS-TB groups.
Data were collected and analyzed using SPSS Version 25. Categorical variables were presented as frequencies and percentages. The chi-square test and Fisher's exact test were employed to analyze correlations between radiologic features and drug resistance status. Statistical significance was set at $p < 0.05$. The Institutional Review Board approved the study (BMC/12/2025).

Results

The study sample comprised 120 patients with multidrug-resistant tuberculosis (MDR-TB) and 120 patients with drug-sensitive tuberculosis (DS-TB), selected according to predefined inclusion criteria and confirmed diagnoses. Males constituted the majority in both groups, accounting for 65% (n=78) in the MDR-TB group and 70% (n=84) in the DS-TB group. The 40–49 year age group was most prevalent in both cohorts, representing 31.7% of MDR-TB and 30% of DS-TB patients. The mean age was 40.2 ± 11.8 years for MDR-TB patients and 41.8 ± 12.1 years for DS-TB patients (Table 1).
Among patients in the MDR-TB group, 112 (93.3%) exhibited large lesions, 8 (6.7%) exhibited medium lesions, and none exhibited small lesions. In comparison, the DS-TB group included 43 (35.8%) patients with small lesions, 55 (45.8%) with medium lesions, and 22 (18.4%) with large lesions (Table 2).
Radiologic features were evaluated by lung zone, focusing on infiltrates, consolidation, and cavities. Their distribution was compared between multidrug-resistant tuberculosis (MDR-TB) and drug-susceptible tuberculosis (DS-TB) groups. DS-TB patients exhibited a significantly higher frequency of infiltrates across all lung zones. In the upper right lung, infiltrates were present in 68.3% of DS-TB patients compared to 36.7% of MDR-TB patients ($P < 0.001$). This pattern was consistent in the upper left lung (61.7% in DS-TB vs. 31.7% in MDR-TB, $P < 0.001$), middle zones (right: 53.3% vs. 26.7%; left: 50% vs. 25%, both $P < 0.01$), and lower zones (right: 30% vs. 15%; left: 33.3% vs. 11.7%, both $P < 0.01$). Conversely, consolidation was significantly more prevalent in MDR-TB patients. In the upper right lung, consolidation was observed in 57.5% of MDR-TB patients compared to 23.3% of DS-TB patients ($P < 0.001$). This trend was also evident in the upper left (55% vs. 21.7%), middle right (46.7% vs. 17.5%), middle left (50.8% vs. 19.2%), and lower zones (right: 20% vs. 9.2%; left: 25% vs. 8.3%), with all differences reaching statistical significance ($P < 0.01$ to $P < 0.001$). The prevalence of cavitary lesions was substantially higher in the MDR-TB group across all lung regions. In the upper right lung, cavities were identified in 58.3% of MDR-TB patients compared to 7.5% of DS-TB patients ($P < 0.001$). Similarly, the upper left (49.2% vs. 6.7%), middle right (39.2% vs. 6.7%), middle left (52.5% vs. 5%), lower right (9.2% vs. 2.5%), and lower left lungs

Table 1. Demographic characteristics between multi-drug resistant tuberculosis and drug-sensitive tuberculosis groups

Characteristic	MDR-TB (n = 120)	DS-TB (n = 120)	P value
Gender			
Male	78 (65%)	84 (70%)	0.44
Female	42 (35%)	36 (30%)	
Age group			
<30 years	22 (18.3%)	30 (25%)	0.18
30–39 years	34 (28.3%)	26 (21.7%)	
40–49 years	38 (31.7%)	36 (30%)	
50–59 years	20 (16.7%)	18 (15%)	
≥60 years	6 (5%)	10 (8.3%)	
Mean ± SD	40.2 ± 11.8	41.8 ± 12.1	0.37

Table 2. Lesion size comparison between multidrug-resistant tuberculosis and drug-sensitive tuberculosis groups

Lesion Size	MDR-TB (n = 120)	DS-TB (n = 120)	P value
Small	0 (0%)	43 (35.8%)	<0.001
Medium	8 (6.7%)	55 (45.8%)	
Large	112 (93.3%)	22 (18.4%)	

(12.5% vs. 3.3%) all demonstrated significantly greater cavitation in the MDR-TB group ($P < 0.001$ to $P < 0.05$) (Table 3).

Cavitation was frequently observed in the MDR-TB group, with notable differences in both size and number compared to the DS-TB group. In the MDR-TB cohort, 76 patients (63.3%) exhibited cavities, and 21 patients (17.5%) had cavities larger than 4 cm. In contrast, among DS-TB patients, 14 (11.7%) had cavities of 4 cm or less, and only 2 (1.7%) had cavities exceeding 4 cm. Solitary cavities were identified in 7 MDR-TB patients (5.8%) and 3 DS-TB patients (2.5%) (Table 4).

Significant variations in extraparenchymal changes were observed between multidrug-resistant tuberculosis (MDR-TB) and drug-sensitive tuberculosis (DS-TB) cases. Pleural effusion occurred more frequently in MDR-TB patients, with left pleural effusion present in 24 cases (20%) and right pleural effusion in 10 cases (8.3%). In comparison, left pleural effusion was identified in 3 cases (2.5%) and right pleural effusion in 2 cases (1.7%) among DS-TB patients. Pleural thickening was also more prevalent in MDR-TB patients, with right pleural thickening observed in 16 cases (13.3%) and left pleural thickening in 11 cases (9.2%), whereas DS-TB patients exhibited minimal pleural involvement (right: 1 case [0.8%], left: 0 cases [0%]). Multiple instances of hilar elevation and tracheal deviation, indicative of chronic volume loss or fibrotic shift, were documented in MDR-TB patients. Specifically, right hilar elevation was noted in 18 cases (15%) and left hilar elevation in 14 cases (11.7%). Right tracheal deviation occurred in 15 cases (12.5%) and left tracheal deviation in 19 cases (15.8%) among MDR-TB patients. These features were less common in DS-TB patients and were statistically significant, except for left-sided hilar elevation (Table 5).

Discussion

The present study found significant differences in chest radiographic features between patients with multidrug-resistant tuberculosis (MDR-TB) and those with drug-susceptible tuberculosis (DS-TB). MDR-TB was associated with larger lesions, more frequent and extensive consolidation and cavitation, and more widespread bilateral and upper lung involvement. In contrast, DS-TB typically presented with smaller lesions and predominant infiltration changes. MDR-TB also demonstrated a higher frequency of pleural, hilar, and tracheal abnormalities. These findings suggest that drug resistance is frequently linked to more severe pulmonary damage. Nevertheless, chest radiography alone cannot confirm drug resistance and should be supplemented with microbiological sensitivity testing.

A primary finding was the marked difference in lesion size between the MDR-TB and DS-TB groups. Ninety-three point three percent of MDR-TB patients exhibited large lesions, compared to only 18.4% of DS-TB patients, while small lesions were exclusive to the DS-TB group. This observation aligns with Icksan et al., who reported that 96% of MDR-TB patients had large lesions compared to 27% of DS-TB patients, with small and medium lesions more common in DS-TB.[3] Rifani et al. similarly found that extensive or moderate radiographic lesions were more frequent in MDR-TB, supporting the association between drug resistance and increased radiographic disease burden.[10] Additionally, a large comparative CT study by Cheng et al. demonstrated greater pulmonary involvement in drug-resistant patients, including whole-lung involvement and multiple structural abnormalities.[11] The consistency of these findings across diverse populations and imaging modalities suggests that increased lesion extent may indicate more advanced or persistent pulmonary disease in drug-resistant tuberculosis.

Several factors may account for the large lesions observed in the MDR-TB group. Ongoing bacterial replication despite ineffective treatment can exacerbate lung damage, and patients with drug resistance may experience disease progression before receiving appropriate therapy. However, lesion size alone is not a definitive indicator of MDR-TB, as severe DS-TB cases can also present with extensive radiographic abnormalities. For example, a national survey in Indonesia reported similar radiographic appearances between DS-TB and MDR-TB, indicating that such differences are not always distinct.[12] Therefore, while lesion size may raise suspicion for MDR-TB, it should not serve as the sole criterion for drug resistance testing.

The distribution of parenchymal abnormalities was also notable. Infiltrates were significantly more common in DS-TB patients across all lung regions assessed, whereas

Table 3. Radiologic findings by lung region between multi-drug resistant and drug-sensitive tuberculosis groups

Radiological Finding	MDR-TB (n = 120)	DS-TB (n = 120)	P value
Infiltrate			
Upper right lung	44 (36.7%)	82 (68.3%)	<0.001
Upper left lung	38 (31.7%)	74 (61.7%)	<0.001
Middle right lung	32 (26.7%)	64 (53.3%)	<0.01
Middle left lung	30 (25.0%)	60 (50.0%)	<0.01
Lower right lung	18 (15.0%)	36 (30.0%)	<0.01
Lower left lung	14 (11.7%)	40 (33.3%)	<0.01
Consolidation			
Upper right lung	69 (57.5%)	28 (23.3%)	<0.001
Upper left lung	66 (55.0%)	26 (21.7%)	<0.001
Middle right lung	56 (46.7%)	21 (17.5%)	<0.001
Middle left lung	61 (50.8%)	23 (19.2%)	<0.001
Lower right lung	24 (20.0%)	11 (9.2%)	<0.01
Lower left lung	30 (25.0%)	10 (8.3%)	<0.001
Cavity			
Upper right lung	70 (58.3%)	9 (7.5%)	<0.001
Upper left lung	59 (49.2%)	8 (6.7%)	<0.001
Middle right lung	47 (39.2%)	8 (6.7%)	<0.001
Middle left lung	63 (52.5%)	6 (5.0%)	<0.001
Lower right lung	11 (9.2%)	3 (2.5%)	<0.05
Lower left lung	15 (12.5%)	4 (3.3%)	<0.05

consolidations were more prevalent in MDR-TB, particularly in the upper and middle lung zones. These findings are consistent with previous comparative radiographic studies. For instance, Icksan et al. reported that infiltrates and ground-glass-type active lesions were more frequent in DS-TB, while consolidations were significantly more common in MDR-TB.[3] Similarly, Zuhriyyah et al. found consolidation to be the most common radiographic abnormality among pediatric patients with drug-resistant TB, with a prevalence of 68% compared to 18% in DS-TB, although their sample included children with various types of drug resistance.[13] Additionally, Gupta et al. demonstrated an association between consolidations, cavitary lesions, and drug

Table 4. Cavity characteristics between multi-drug resistant and drug-sensitive tuberculosis groups

Cavity Feature	MDR-TB (n = 120)	DS-TB (n = 120)	P value
Cavity ≤4 cm	76 (63.3%)	14 (11.7%)	<0.001
Cavity >4 cm	21 (17.5%)	2 (1.7%)	<0.001
Solitary cavity	7 (5.8%)	3 (2.5%)	0.18
Multiple cavities	82 (68.3%)	10 (8.3%)	<0.001

resistance in children.[14]

The higher prevalence of infiltrates observed in DS-TB requires careful interpretation, as infiltrate opacities are non-specific indicators of active TB disease. An Indonesian national study identified infiltrates, cavities, and consolidation as the primary radiographic abnormalities in DS-TB, while nodules were the only distinctive feature for MDR-TB in multivariate analysis.[12] In contrast, the present study demonstrated a stronger distinction between DS-TB and MDR-TB regarding infiltrates and consolidation. Discrepancies between studies may be attributed to differences in patient selection criteria, disease severity, definitions of radiographic categories, imaging timing, and local patterns of drug resistance.

Cavitation emerged as the primary structural characteristic consistently differentiating the groups. Cavitation was significantly more common in MDR-TB patients across all lung regions. Specifically, cavities measuring 4 cm or less were detected in 63.3% of MDR-TB patients and only 11.7% of DS-TB patients. In comparison, cavities larger than 4 cm were found in 17.5% and 1.7% of patients, respectively. The overall number of cavities was also significantly higher in MDR-TB patients (68.3% versus 8.3%). Previous imaging studies support these findings. For example, Kim et al. reported a significantly higher frequency of cavitation in MDR-TB patients. They observed that multiple cavities (more than three) were present only in MDR-TB patients.[15] Yeom et al. similarly demonstrated a higher cavitation rate in primary MDR-TB and found that multiple cavities are independently associated with primary MDR-TB.[16] Cha et al., in a comparison of DS-TB, MDR-TB, and extensively drug-resistant TB (XDR-TB), reported multiple cavities in 40% of MDR-TB patients compared to 15% of DS-TB patients, along with a higher mean number of cavities in MDR-TB.[17] The magnitude of the difference observed in the present study is consistent with evidence from both chest X-ray and CT studies, although absolute frequencies vary between populations.

Biological plausibility supports the association between cavitation multiplicity and drug resistance. Cavitation indicates substantial caseous necrosis and tissue destruction, creating conditions conducive to a high bacterial burden. Multiple cavitations may therefore reflect extensive and chronic lung damage. However, multiple cavitations are not exclusive to MDR-TB. For example, Wáng et al. found that multiple cavities, particularly when three or more are present, offer relatively high specificity for MDR-TB but lack sufficient sensitivity.[18] These findings reinforce the idea that multiple, extensive cavitations indicate MDR-TB.

The results indicate that both MDR-TB and DS-TB infections predominantly affect the upper lobes; however, consolidation and cavitary lesions are considerably more frequent in MDR-TB. Cha et al. corroborated these findings, reporting that the primary sites of lesions in MDR/XDR-TB cases were the upper and middle lung regions.[17] Similarly, Yeom et al. observed significantly greater bilateral parenchymal involvement in primary MDR-TB and demonstrated that bilateral involvement and multiple cavities are associated with MDR-TB [16]. Furthermore, Cheng et al., through comprehensive CT assessment, found that whole lung involvement, multiple cavities, thick-walled cavities, bronchial dissemination, and bronchiectasis are more prevalent in drug-resistant TB.[11]

The present study observed a predominance of upper zone involvement, consistent with the post-primary distribution of pulmonary tuberculosis in adults. The notably high incidence of upper zone cavities and consolidation in MDR-TB may reflect a greater extent of parenchymal disease progression rather than a specific anatomical predisposition to drug resistance. This distinction is important, as upper lobe predominance is also observed in DS-TB. Therefore, differentiation between MDR-TB and DS-TB should consider both upper lobe involvement and specific lesion characteristics.

This study identified a higher prevalence of pleural effusion, pleural thickening, hilar elevation, and tracheal deviation in patients with MDR-TB compared to those with DS-TB. These findings are clinically significant, as hilar elevation and tracheal deviation may indicate chronic volume loss, fibrosis, or structural distortion resulting from chronic disease. Wang et al. conducted a systematic review demonstrating that MDR-TB is associated with

Table 5. Non-parenchymal radiologic findings between multi-drug resistant and drug-sensitive tuberculosis groups

Finding	MDR-TB (n = 120)	DS-TB (n = 120)	P value
Right pleural effusion	10 (8.3%)	2 (1.7%)	0.01
Left pleural effusion	24 (20%)	3 (2.5%)	<0.001
Right pleural thickening	16 (13.3%)	1 (0.8%)	<0.001
Left pleural thickening	11 (9.2%)	0 (0%)	<0.001
Right hilar elevation	18 (15%)	3 (2.5%)	<0.001
Left hilar elevation	14 (11.7%)	2 (1.7%)	<0.001
Right tracheal deviation	15 (12.5%)	3 (2.5%)	<0.001
Left tracheal deviation	19 (15.8%)	3 (2.5%)	<0.001

greater disease extent, increased bilateral involvement, pleural involvement, bronchiectasis, and lung volume loss, although these features are not diagnostic in isolation.[18] Additionally, Cheng et al. reported a higher prevalence of encapsulated pleural effusion and atelectasis in drug-resistant tuberculosis.[11] In contrast, Oriekot et al., in a Ugandan chest radiograph study comparing DS-TB with rifampicin-resistant TB, found considerable overlap in consolidation, cavities, and other radiographic findings, with no statistically significant differences for several major abnormalities.[19]

There is considerable variability among different studies. The presence of pleural involvement and volume loss may not be attributable solely to drug resistance; these findings could also indicate chronic infection, prior treatment, severe illness, or complications. The current study does not establish whether the higher frequency of pleural and volume loss in MDR-TB patients is a consequence of drug resistance or merely reflects more advanced disease.

Clinical implications

These findings have practical implications, particularly in settings where molecular drug resistance testing is not immediately available. Patients presenting with large bilateral masses, extensive consolidation, multiple cavitations, and architectural or pleural changes should be prioritized for urgent microbiological testing for drug resistance. Chest radiography remains cost-effective, widely accessible, and easily repeatable, making it especially valuable in low-resource environments. However, while certain radiographic features may raise suspicion for MDR-TB, they are not definitive. This is supported by systematic data demonstrating considerable overlap between MDR-TB and DS-TB,[18] as well as studies that found no clear association between specific radiographic changes and disease progression.[12,19]

Strengths

This study possesses several strengths. It included equal numbers of MDR-TB and DS-TB patients and systematically evaluated multiple radiographic characteristics. The study assessed lesion distribution across six lung regions. Two experienced radiologists independently reviewed the radiographs while blinded to drug resistance status, and they resolved discrepancies by consensus to minimize observer bias.

Limitations

This study has several limitations. First, its retrospective design limits causal inference and introduces potential bias. Second, being conducted at a single institution may reduce generalizability. Third, chest radiography is less sensitive than computed tomography for detecting minor findings. First, its retrospective design limits causal inference and introduces potential bias. Second, the single-institution setting may reduce generalizability. Third, chest radiography is less sensitive than computed tomography for detecting minor parenchymal abnormalities. Fourth, although demographic differences between groups were not significant, the analysis did not adjust for confounding factors such as prior TB treatment, HIV infection, diabetes, smoking, disease duration, and severity. Finally, radiographic findings lack the specificity required to replace microbiological drug susceptibility

testing. DS-TB is mainly associated with infiltration changes.

Conclusion

This study demonstrates a distinct radiographic pattern associated with MDR-TB characterized by larger lesions, more extensive consolidation, substantially greater cavitation, and particularly frequent multiple cavities, together with more frequent pleural and architectural abnormalities. In contrast, DS-TB showed a greater predominance of infiltrative changes. These findings are generally consistent with the international literature, particularly regarding the association of multiple cavities and extensive disease with drug resistance, although differences among studies emphasize that no single radiographic feature is sufficiently specific for diagnosis. Chest X-ray therefore has an important complementary role in raising early suspicion of MDR-TB and guiding the urgency of microbiological investigation, particularly in resource-limited settings, but definitive classification should remain dependent on appropriate drug-susceptibility testing.

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