

Thoracic Ultrasonography Findings Pathognomonic of Pulmonary Tuberculosis: A Case of Baraka Health Center, Mathare Slum - Kenya

Alloysius Omoto Luambo

Abstract— Chest ultrasonography, intended for lung, pleura, and mediastinum is a safe, non-invasive medical imaging modality in both affluent and resource-limited settings in respiratory diseases detection including pulmonary Tuberculosis. The purpose of this study is to inform clinicians and policymakers on efficient use of thoracic ultrasound in the screening of tuberculosis and to enrich the existing literature on ultrasonography use in pulmonary Tuberculosis management. This was a hospital based cross-sectional study at Baraka Health center-Mathare slum. Patients presenting at the outpatient section irrespective of age were screened to be included in the study. On the first day, participants with suggestive symptoms of tuberculosis were screened by performing a comprehensive respiratory examination, measuring erythrocyte sedimentation rate and performing chest ultrasonography. Exhaustion of study screening protocols ushered in use of Kenya's ministry of health guidelines in TB diagnosis including a chest x-ray interpreted by a radiologist. Out of 100 participants who met the inclusion criteria 80 (80%) provided consent to be enrolled into the study. Majority were male 63.8% with a mean age of 35.83 ± 15.6 years. The most prominent thoracic ultrasound features identified were lung cavitation and consolidation (52.8%) pleural thickening (77.4%) and sub-pleural nodes (52.8%). In conclusion, Thoracic ultrasound is a safe and effective procedure to visualize pleural space, mediastinum and lung parenchyma in pulmonary tuberculosis screening. Pleural thickening can be identified by ultrasound in more than 77.4% of PTB patients. For precise diagnosis of pulmonary tuberculosis other supporting investigation are recommended to complement thoracic ultrasonography.

Index Terms— Lung ultrasound, pulmonary tuberculosis, Kenya.

I. INTRODUCTION

Tuberculosis is now the world's leading cause of death from a single infectious agent. Kenya is listed by the WHO among the 30 high burden TB countries. To achieve the "End TB 2035" target of 90 reduction in TB incidence rate by 2035, an acceleration of the present decline rate is urgently needed. Screening and accurate diagnosis in low resource setting is the first pillar of end TB campaign¹. Chest ultrasonography, intended for lung, pleura, and mediastinum is becoming an attractive, non-invasive medical imaging modality in both affluent and resource-limited settings in diseases diagnosis². Despite the advance in diagnostic, a considerable proportion of TB cases reported to WHO is still clinically diagnosed, for example, in 2016, only 57% of pulmonary TB cases reported to WHO were bacteriologically confirmed¹. When Diagnosis

is made, it is often difficult and mainly relies on clinical criteria and simple laboratory examinations³. Clinically diagnosed Tuberculosis may be explained by delays in seeking treatment due to structural factors like distance to health facilities as experienced in most parts of Africa and limited diagnostic methods. Moreover, when a diagnostic apparatus is available, many patients present with non-specific symptoms and negative laboratory exams. This delay of diagnosis aggravates the prognosis of the disease². Cultural and molecular diagnostic methods are not available in most health facilities, Studies have shown that delay in TB diagnosis and treatment is a critical problem in TB containment⁴.

A Kenyan TB survey noted that a comparison of the distribution (TB prevalence rate) and the Kenya case notification rates of 2015 by age group showed that notification rates were lower than the survey prevalence rates⁵. Some of the documented factors leading to disparity in case identification and notification of TB in Kenya are lack of finances to seek treatment and misinterpretation of early symptoms. Half of the people diagnosed with TB were not identified through symptom screening nor cough, this implies, the need of employing more innovative screening techniques to increase TB case identification⁶. The standard diagnosis of TB in Kenya is Sputum for microscopy, unfortunately, this test is only available at health centers, sub-county, and county referral hospitals but not at dispensaries. This may delay TB diagnosis⁴.

Gene Xpert is another test recommended for TB diagnosis, unfortunately, there are only 189 gene Xpert machines serving an entire population of more than 46 million Kenyans. This may delay diagnosis further⁶. A chest x-ray is another supportive investigation that is highly sensitive in tuberculosis identification which is done at the patient's expense⁶. This has negative economic implications among TB patients' households and also delays case identification and hence prolongs TB agony on patients. Thoracic ultrasound provides a safe, fast, and less costly alternative to a chest x-ray.

Chest ultrasonography is increasingly being used for the diagnosis of lung diseases. Thoracic ultrasonography is sensitive and specific imaging modality for pneumothorax, pneumonia, and pleural effusion². Advantages of ultrasonography are that it is free of ionizing radiation; can be performed by the clinician at the bedside and is easily reproducible; making it a suitable tool for diagnosis, prompt management decisions, and monitoring of treatment response in tuberculosis and other diseases. Training of chest

ultrasound is relatively easy and a clinician is expected to be competent in its use after 30 supervised examinations. Further development of portable low-cost ultrasound machines will subsequently bring down the cost of TB diagnosis on patients in low resource settings ⁷.

II. PROBLEM STATEMENT

An estimated 10 million people developed Tuberculosis in 2017 but only 6.4 million (61%) were notified ⁵. One-third of the world is infected with tuberculosis, with Africa harboring about 29% of those infected clinically ⁸. Kenya is listed by the World Health Organization among the 30 high burden TB countries ¹. Clinically diagnosed TB is more reported to WHO than bacteriologically diagnosed TB. Despite the considerable investment done by the government and partners in TB care and prevention in the past 20 years the disease still ranks high among the cause of deaths. Finding people and successfully treating them is therefore an important priority in the country ⁵. Pulmonary tuberculosis is a common presentation but diagnosis can be challenging due to non-specific signs and symptoms. Difficulties in obtaining adequate samples make case detection and management difficult, mostly in children ⁷. Chest ultrasound is a cheaper and safer screening technique if combined with other methods in making tuberculosis diagnosis.

III. STUDY JUSTIFICATION

Data on the use of chest ultrasound in the diagnosis of thoracic Tuberculosis is limited ⁷. It is currently unclear if thoracic ultrasonography could play a clinical role in diagnosing or excluding active tubercular chest lesions². Chest radiography is expensive to a community that lives on less than one dollar a day. Tuberculosis affects people of low social economic status more, providing a cheaper thoracic visualization through ultrasonography and combining it with ESR and symptoms on presentation will solve most of our patient's financial woes.

IV. STUDY RATIONALE

This study will inform policymakers on the use of thoracic ultrasound in the diagnosis of tuberculosis among slum dwellers. The results will enrich the existing literature on ultrasonography use in Tuberculosis diagnosis. Trilogy of thoracic ultrasonography, symptomatology, and Erythrocyte Sedimentation Rate may form an efficient screening technique that will increase the rate of Tuberculosis screening. Early and prompt treatment of TB reduces transmission of the disease.

V. METHODOLOGY

A. Research design

A hospital based cross-sectional research design has been employed in generating data for the study. On the first day, participants with suggestive symptoms of tuberculosis were screened by measuring ESR and performing chest ultrasonography. Comprehensive respiratory examination was performed before ultrasonography. Exhaustion of study's screening protocols ushered in use of Kenya's ministry of health guidelines in TB diagnosis including a chest x-ray

interpreted by a radiologist. Positively screened participants were sent to the TB clinic for sputum microscopy, chest x-ray and independent determination of enrollment into TB care by the clinician at the clinic.

B. Study location

This was a hospital-based study which was carried out at German Doctors, Baraka Health Center, located at the heart of Mathare slum (area section 4A). Baraka Health Center is a facility funded and operated by the German Doctors organization. It serves an average of 250 patients per day at no cost.

C. Sampling method

Judgmental non-probability method was used in sample selection

$$N = \frac{(1.96)^2 (0.0056) (1 - 0.0056)}{(0.05)^2} = 9$$

Kenya TB prevalence = 558 cases per 100,000 people

$$Z^2 = 1.96^2$$

$$P = 0.0056$$

$$d^2 = 0.05^2$$

After adding 20% of estimated missing data , the total

number to be sampled is 11

D. Target population

All patients presenting to the outpatient department with respiratory symptoms presumed to be pulmonary tuberculosis.

E. Inclusion criteria

Patients of all age groups presenting to the triage department with symptoms suggestive of TB.

F. Exclusion criteria

Known Tuberculosis patients on treatment and other patients not marked as TB presumptive from the triage area.

G. Ethics

Permission to conduct research and collect data was sought from the hospital administration. Consent was sought from the study subjects and they had an option of opting out of the study at any time. There was no financial benefit extended to the participants and that was clearly highlighted. There is no conflict of interest from the researcher in relation to this study.

VI. RESULTS

A. Bio-demographic data

A total of 100 participants were involved in the study and 80 of them completed the study which represented 80% of the total subjects. About 66.5% of the 80 participants were correctly diagnosed with Pulmonary Tuberculosis through thoracic ultrasonography. Majority of the participants (47.5%) had primary school level education. Most of study participants (92.5%) resided within Nairobi with 85% living in Eastland area while 7.5% were living in other areas within Nairobi. Alcohol (11%) is the single most abused drug among the participants with majority of the participants abusing both alcohol and cigarettes simultaneously. Informal sector (56.3%) provided a vast portion of employment with the unemployed (41.3%) also forming a significant proportion.

Table 1 : Recreational drug use

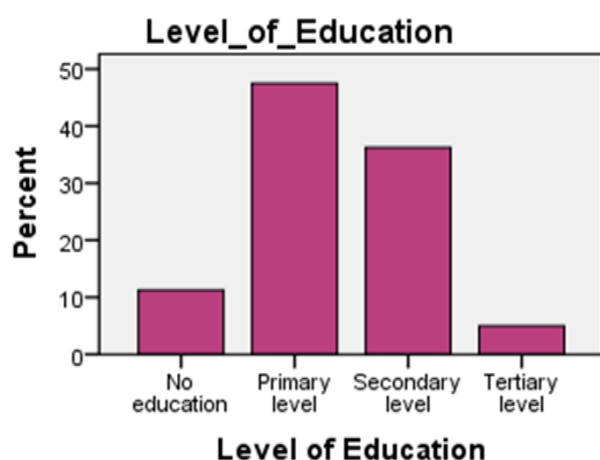
RECREATIONAL DRUG USE

	Frequency	Percent %
Cigarette	2	2.5
Alcohol	11	13.8
Both	15	18.8
None	52	65.0
Total	80	100.0

Figure 1: Level of education

B. Ultrasonography findings suggestive of PTB

The most prominent features identified via thoracic



ultrasonography included pleural effusion, B-lines, mediastinal lymph nodes, apical lymph nodes, pleural thickening, sub-pleural nodes, lung consolidation and cavitation.

Table 2 : Thoracic ultrasound: Features suggestive of pulmonary tuberculosis

Lung ultrasound features	Frequency out of 53 TB cases	Percentage %
Lung cavitation and consolidation	28	52.80
Pleura thickening	41	77.40
B- lines	38	71.70
Sub-pleural nodes	28	49.10
Pleural effusion	26	32.50
Mediastinal nodes	21	39.60
Apical Lymph-nodes	19	38.80

Lung consolidation and cavitation



Pleura thickening



B-lines

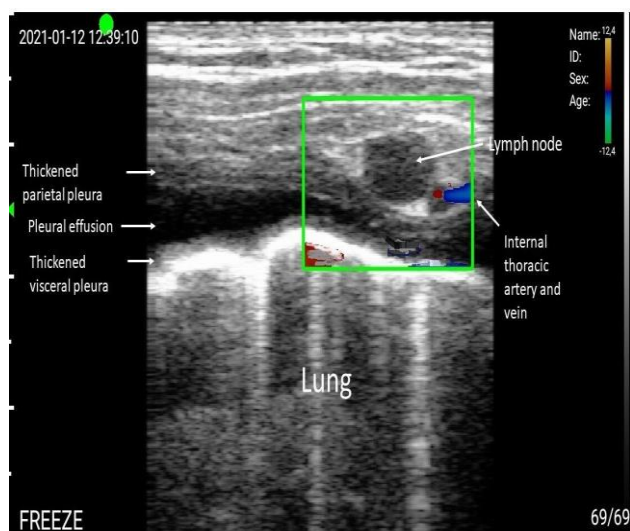


Thoracic Ultrasonography Findings Pathognomonic of Pulmonary Tuberculosis: A Case of Baraka Health Center, Mathare Slum - Kenya

Sub pleural node



Pleural effusion



Apical Node



VII. DISCUSSION

Radiological investigations commonly used for PTB

diagnosis in low resource setting is Chest x-ray. In this study chest x-ray was preserved for diagnosis confirmation using the World Health Organization TB diagnosis standards that recommends use of composite approach uniting radiology with three other technologies (sputum microscopy, culture based methods and molecular testing)¹. There is scarcity of literature on chest ultrasonography and the available studies majored on children⁹. Chest ultrasound of a HIV infected patient with PTB showed a shred sign representing consolidation. Another study, comprising of ten adults with milliary PTB, described what Presented as bilateral B-lines in multiple lung zones plus sub pleural lesions on chest ultrasound. A cohort study including 60 adults with PTB found hypo-echoic sub-pleural nodules (smaller than 1 cm diameter) as the commonest ultrasound finding (Chest ultrasonography in patients with HIV: a case series, 2016). This was equally evident in this study that recorded 52.8% of subjects to have had consolidation and B-lines was a notable sign in 71.7% of the participants.

Previous studies showed that chest ultrasound demonstrated pleural effusion more commonly in children with microbiologically confirmed PTB than in children with other respiratory diseases. Mediastinal ultrasound was feasible in visualizing lymphadenopathy, children with PTB had large lymph nodes than children with other respiratory diseases. Consolidation was common in children diagnosed with PTB compared to those with other respiratory diseases but resolution with consolidation was slower in children with confirmed PTB⁹.

Our study compared with another one that performed chest ultrasound on PTB patients and found out all patients had abnormal findings, the most frequent was a sub-pleural node (SUN), which was mostly multiple and also found in radiological normal areas. Other findings were lung consolidation, cavitation, milliary patterns made of miniature sub-pleural nodes, pleural and pericardial effusion¹⁰. A systematic review of literature unveiled chest ultrasonography was able to identify mediastinal lymph nodes in as many as 67% of patients with negative chest radiography. The suggested future diagnostic or feasibility trials should focus on the detection of tuberculosis-related pleural effusion, residual pleural thickening, lymphadenopathy, TB parenchymal patterns, and the use of chest ultrasound biopsy guidance². The findings from this meta-analysis found 5 main application of thoracic TB emergence as follows

- Diagnosis of pleural effusion. Effusion seemed to facilitate the determination of the underlying lung lesion.
- Chest ultrasound seemed to be accurate in determining residual pleural thickening.
- Focused on the use of chest ultrasound on biopsies of chest ultrasound.
- Aimed at identifying a pathological mediastinal disease, lymph nodes, among children.
- Describe parenchymal patterns.

VIII. CONCLUSION

Thoracic ultrasound is an important procedure to visualize pleural space, mediastinum and lung parenchyma in

pulmonary tuberculosis screening. For accurate diagnosis of pulmonary tuberculosis other supporting investigation are recommended to complement thoracic ultrasonography. The most prominent chest ultrasound findings suggestive of Pulmonary Tuberculosis are; pleural thickening, pleural effusion, lung cavitation, lung consolidation, apical lymph nodes, B-lines, Sub-pleura nodes and mediastinal lymph nodes.

IX. ACKNOWLEDGMENT

The author would like to thank Mr. George Audi, Dr. Ruth Laurenz, Edna Kenyanya, Ruth Nyokabi, Moses Apela and the entire German Doctors- Baraka Health Center staff.

REFERENCES

- [1] Agostinis, P., Copetti, R., Lapini, L., Badona Monteiro, G., N'Deque, A., & Baritussio, A. (2017). Chest ultrasound findings in pulmonary tuberculosis. *Tropical Doctor*.
<https://doi.org/10.1177/0049475517709633>
- [2] Anazodo Nnoli, M. (2012). Prevalence of Tuberculosis-HIV Coinfection and Relationship between Tuberculosis and CD4/ESR in HIV Patients in Niger Delta Region of Nigeria. Article in *IOSR Journal of Dental and Medical Sciences*, 2(4), 1–04.
<https://doi.org/10.9790/0853-0240104>
- [3] Bregani, E. R., Valcarengi, C., Tien, T. Van, & Monzani, V. (2013). Suggestive criteria for pulmonary tuberculosis in developing countries. *International Journal of Mycobacteriology*.
<https://doi.org/10.1016/j.ijmyco.2013.08.004>
- [4] Di Gennaro, F., Pisani, L., Veronese, N., Pizzol, D., Lippolis, V., Saracino, A., Monno, L., Huson, M. A. M., Copetti, R., Putoto, G., & Schultz, M. J. (2018). Potential diagnostic properties of chest ultrasound in thoracic tuberculosis—A systematic review. In *International Journal of Environmental Research and Public Health*.
<https://doi.org/10.3390/ijerph15102235>
- [5] Enos, M., Sitienei, J., Ong'ang'o, J., Mungai, B., Kamene, M., Wambugu, J., Kipruto, H., Manduku, V., Mburu, J., Nyaboke, D., Ngari, F., Omesa, E., Omale, N., Mwirigi, N., Okallo, G., Njoroge, J., Githiomi, M., Mwangi, M., Kirathe, D., ... Weyenga, H. (2018). Kenya tuberculosis prevalence survey 2016: Challenges and opportunities of ending TB in Kenya. *PLoS ONE*, 13(12).
<https://doi.org/10.1371/journal.pone.0209098>
- [6] Heuvelings, C. C., B  lard, S., Andronikou, S., Jamieson-Luff, N., Grobusch, M. P., & Zar, H. J. (2019). Chest ultrasound findings in children with suspected pulmonary tuberculosis. *Pediatric Pulmonology*, 54(4), 463–470. <https://doi.org/10.1002/ppul.24230>
- [7] Heuvelings, C. C., B  lard, S., Andronikou, S., Lederman, H., Moodley, H., Grobusch, M. P., & Zar, H. J. (2019). Chest ultrasound compared to chest X-ray for pediatric pulmonary tuberculosis. *Pediatric Pulmonology*, 54(12), 1914–1920. <https://doi.org/10.1002/ppul.24500>
- [8] Kenya Ministry of Health. (2019). National Strategic Plan for Tuberculosis, Leprosy and Lung Health 2019-2023. Moh.
<https://www.nltf.co.ke/download/national-strategic-plan-2019-2023/>
- [9] Mbuthia, G. W., Olungah, C. O., & Ondicho, T. G. (2018). Health-seeking pathway and factors leading to delays in tuberculosis diagnosis in West Pokot County, Kenya: A grounded theory study. *PLoS ONE*, 13(11), 1–17.
<https://doi.org/10.1371/journal.pone.0207995>
- [10] WHO. (2017). Global Tuberculosis Report 2017: Leave no one behind - Unite to end TB. In WHO - Technical Report Series; 727.
http://www.who.int/tb/publications/global_report/gtbr2017_main_text.pdf?ua=1