ORIGINAL RESEARCH PAPER

Ultrasound-guided lymph node biopsies: Feasible and safe use of pathology services in a resource-limited, high TB/HIV prevalence setting

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ABSTRACT

Background: Enlarged lymph nodes (LN) pose diagnostic challenges for people with HIV (PWH). While tuberculosis (TB) is a common cause in low-income settings, lymphomas and Kaposi's sarcoma must also be considered. Ultrasound and symptoms cannot distinguish between these conditions, and histology is often needed, but limited resources in low-income countries restrict sampling. To minimize the need for excisional biopsies, we introduced an algorithm for ultrasound-guided core-needle biopsies (CNB) after negative fine-needle aspiration (FNA) results by Xpert-Ultra (Cepheid, USA).

Methods: At the Lighthouse clinic in Lilongwe, Malawi, patients with peripheral lymphadenopathy underwent an ultrasound-guided FNA. Negative Xpert-Ultra results prompted CNB using Tru-Cut needles, with samples sent for pathology. We retrospectively analyzed 12 months of cross-sectional data, including histology results and abdominal ultrasound findings.

Results: In 2024, 53 CNBs were performed, 96% in PWH. No significant complications were observed. A conclusive diagnosis was reached in 77% of cases, with the most common diagnoses being hematological malignancies (54%), reactive LN (15%), Kaposi's sarcoma (12%) and metastatic carcinoma (10%). Infections, including

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granulomatous inflammation were found in 10% of cases. Hypoechoic spleen lesions were more frequent in patients with hematological diseases (p=0.03).

Conclusion: Ultrasound-guided CNB of enlarged peripheral LN is a safe, effective addition to routine ART clinics. After negative Xpert-Ultra FNA, hematological malignancies were common. Abdominal ultrasound findings were frequently abnormal overall and hypoechoic spleen lesions were more common in patients with hematological abnormalities.

Key words: HIV, lymphadenopathy, ultrasound-guided biopsy, low-resource setting, pathology

Introduction

Enlarged lymph nodes (LN) are a diagnostic clinical challenge in people with HIV (PWH), particularly in settings with high tuberculosis (TB) prevalence. TB, caused by *Mycobacterium tuberculosis* (MTB), is often difficult to diagnose, and delayed or missed TB diagnoses will further increase the risk of high early mortality (1,2). Africa and South-East Asia are estimated to have the highest TB incidence rates (3). In 2023, approximately 19% of TB diagnoses in the African region were seen in PWH and overall 12% were diagnosed with extra-pulmonary TB (4). A meta-analysis explored TB lymphadenitis in various African countries and noted that the pooled prevalence of HIV in the cohorts was 52% (5). In further studies from South Africa, TB remained the most common lymph node pathology in PWH, even in more modern antiretroviral therapy (ART) eras (6,7). Nevertheless, while TB is the most common cause of lymphadenopathy and the cause with the most widely available treatment, other differential diagnoses need to be considered. Some hematological malignancies, in particular lymphomas, and also Kaposi's sarcoma, are treatable causes of lymphadenopathy even in resource-limited settings, but generally require histological diagnosis (8–10). Rarer inflammatory conditions can often only be detected and diagnosed if tissue is obtained for histology (11). However, there is a gap in ensuring rapid and accurate diagnosis for these patients due to a dearth of availability of pathologic services in low-income countries. There is an urgent need to develop methods for combining additional diagnostic tools where pathology services are less available (12). For example, ultrasound is a useful imaging tool in the evaluation of enlarged peripheral lymph nodes in cervical, axillary and inguinal areas. Gray-scale sonography features like the LN shape can help to differentiate benign and malignant nodes (13). Reactive nodes tend to be more oval (defined by a short axis–to–long axis ratio [S/L] < 0.5) while malignant nodes tend to be more round ([S/L] > 0.5). While the S/L ratio can be helpful in differentiating reactive from diseased nodes it shows considerable overlap when assessing tubercular, metastatic and lymphoma lymph nodes (14). Symptom-based screening for tuberculosis is known to have a poor specificity in PWH (15,16). Xpert-Ultra (Cepheid, USA) is a World Health Organization (WHO)-recommended rapid nucleic acid amplification test (NAATs) that is widely used for the detection of MTB and rifampicin resistance. Xpert-Ultra is also recommended for the diagnosis of extrapulmonary TB in select sample types (e.g., cerebrospinal fluid, lymph nodes, pleural fluid, or pericardial fluid amongst others) (17). For lymph node fine-needle aspirates (FNAs) a Cochrane review reported that Xpert-Ultra had a diagnostic sensitivity and specificity of 70% and 100% respectively (18). To reduce the number of required excisional biopsies for histological investigations, we implemented an algorithm that provided ultrasound-guided core-needle biopsies (CNB) of LN tissue in those patients whose ultrasound-guided FNAs already tested negative by Xpert-Ultra, inspired by a similar program implemented in a lymph-node specific clinic in Cape Town, South Africa (7). We describe the training and program implementation as well as the diagnostic and ultrasound findings for this cohort in Malawi.

Methods

Cross-sectional data was collected retrospectively, spanning a 12-month period, for all participants that had an ultrasound-guided core-needle biopsy performed therein. A diagnostic algorithm was established for adults and adolescents (aged >14 years) in whom peripheral (cervical, axillary and/or groin) lymphadenopathy had an unclear cause after Xpert-Ultra of LN FNA. PWH were included irrespective of the differential diagnosis, whereas individuals without HIV were only included if TB was considered an initial differential diagnosis. The diagnostic algorithm was titled "Unclear Lymphnode Swelling streamlined examination system" (ULySSES, Figure 1). An FNA of the LN was performed, after which the aspirate was flushed in 1-2cc of normal saline or directly in the GeneXpert buffer and a Xpert-Ultra test performed. When the FNA detected MTB, treatment for TB was initiated according to national guidelines and recorded elsewhere. For patients testing Xpert-Ultra negative (or in those who were referred with a negative Xpert-Ultra FNA result from other clinics), core-needle biopsies of an enlarged and safely accessible LN were performed and are the focus of this study. Single-use 16G (15 cm length) semi-automatic Tru-Cut needles were used per manufacturer standard operating procedures, three to five cylinders obtained, and placed in formalin. Whenever possible, prior to biopsy, all patients routinely underwent the following procedures: physical exam, full blood count, and an abdominal ultrasound exam with the focused assessment with sonography for HIV-associated TB (FASH) protocol (19). The FASH protocol assesses for pericardial, pleural and abdominal effusions as well as enlarged abdominal lymph nodes and hypoechoic lesions in the spleen (19). Contraindications for biopsy were platelets below 20,000/ml, known bleeding disorders or nodes considered inaccessible by the clinician. Patients were observed for 30 minutes to one hour after procedure for bleeding or other complications.

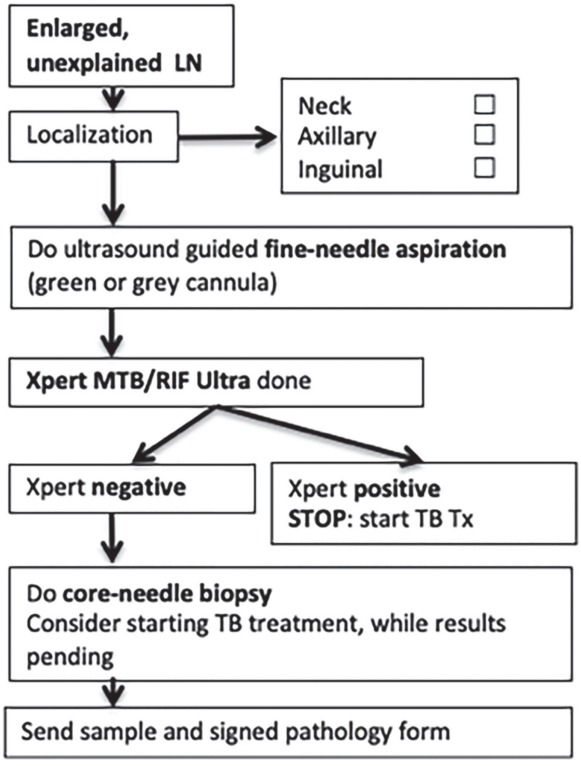

Figure 1. Algorithm (Unclear Lymph node Swelling Streamlined Examination System, ULySSES) using a primary ultrasound-guided FNA for Xpert[R]MTB/RIF-Ultra as a gating mechanism for core-needle biopsy and histology assessment.

Clinical setting and training

The biopsy program was implemented at Lighthouse Trust clinic (LH), a WHO-recognized Centre of Excellence for integrated HIV care, operating multiple large HIV clinics in Malawi (20). The LH site at Kamuzu Central Hospital (KCH) provides free outpatient HIV care for more than 13,000 patients on antiretroviral therapy (ART). At LH, staff routinely use point-of-care ultrasound (POCUS) during HIV clinic visits to detect signs of disseminated TB using the FASH protocol. Multiple clinicians are thus trained and have 3+ years of experience using ultrasound. Two black and white ultrasound machines were used (Mindray DP-30 with convex 35C50EA and linear 75L38EB probes, Mindray DC-30 with convex 35C50P and linear 75L38P probes, (Mindray, China)); colour flow mapping was not employed. Beyond the regular use of POCUS, LH clinicians have no further formal ultrasound training, therefore a short one-day training was conducted: 6-8 clinicians participated in the training - guided by two trainers. After an initial lecture using slides and videos

(for training material see Supplementary material 1) as well as discussion of indications, risks and contraindications (overall approx. 90 minutes), a practical training was conducted for approx. three hours. For these, two phantom types were used (a "gelatine phantom" for probe-needle coordination and a "goat-meat-and-skin phantom" to practice incision and needle insertion). For details of phantom characteristics and instruction for preparation, see Supplementary material 2.

Pathology investigations and data evaluation

Diagnoses were pathologically confirmed at KCH/University of North Carolina (UNC) Project Malawi pathology lab (21) using H&E stained biopsy sections and a limited panel of immunohistochemistry (CD3, CD20, CD30, CD45 and LANA). Ziehl-Neelsen stains were done when the H&E stains gave the suspected diagnosis of non-tuberculous mycobacteria. Weekly real-time telepathology consultation involving two to four board-certified pathologists in Lilongwe and Chapel Hill rendered a consensus opinion. The pathology workflow at the KCH/UNC pathology lab has been previously described (22,23). The objective of this study was to describe the implementation and findings of a program for ultrasound-guided core-needle biopsies in our setting. Data were retrospectively extracted from patient files and forms, anonymized and collected in a protected file. Statistics were calculated using Microsoft Excel (Redmond, WA, USA, 2024) and MedCalc online software (https://www.medcalc.org , accessed 2025) using Chi-square and the Mann-Whitney U test. When data were missing, participants were excluded from that analysis. No formal sample size calculation was done, but all eligible patients who had ultrasound-guided core-needle biopsies as part of our program over the study period were included. All investigations and data collection were part of routine clinical care and processes at LH; approval was granted by the Malawi National Health Science Research Committee for the collection and use of clinical and programmatic data (NHSRC Protocol #2812).

Results

Cohort description

From January to December 2024, 53 patients with enlarged LN who presented at LH clinics had core needle biopsies done. The median age of included patients was 39 years (IQR 24–49), and 31 (59%) were male (Table 1). The majority (44/46 (96%)) with documented HIV results were living with HIV. Out of these, 35 (80%) were on ART (less than one month n=7, one to three months n=9, more than three months n=19). A CD4 count was available for 33 (73%) wherein the median CD4 was 255 cells/μl. Eleven patients (33%) had a CD4 count <200 cells/μl, implying advanced HIV disease. No significant procedural complications (e.g., excessive bleeding requiring hospitalisation or transfusion, or infections requiring antibiotic treatment) occurred.

Histological diagnoses

A conclusive pathological diagnosis was reached in the majority (41/53 (77%)) while the remaining samples were reported to not represent lesional tissue (n=7 (13%)), were poorly preserved (n=3 (6%)), insufficient size for assessment (n=1 (2%)) or the sample/result was lost (n=1 (2%)). In this cohort, wherein an initial LN Xpert-Ultra was negative, the most frequently identified underlying pathologies were hematological malignancies in 22 (54%; 95% CI 38-69). These malignancies included non-Hodgkin lymphoma (NHL) (n=19, 46%; 95% CI 31-62), Hodgkin lymphoma (HL) (n=2, 5%; 95% CI 0-12) and multicentric Castleman disease (MCD) (n=1, 2%; 95% CI 0-7). Other diagnoses detected were reactive LN (n=6, 15%; 95% CI 4-26), Kaposi sarcoma (n=5, 12%; 95% CI 2.0-22) and metastatic carcinoma (n=4, 10%; 95% CI 0.5-16). Infection was deemed the cause of enlarged LN in four (10%; 95% CI 0.5-16.) with histological features in keeping with possible MTB such as granulomatous inflammation in two (5%), one described as an "abscess" and one with likely disseminated non-tuberculous mycobacteria (NTM).

Table 1. Characteristics, symptoms, laboratory, and abdominal ultrasound findings of patients undergoing ultrasound-guided core-needle lymph node biopsy for enlarged peripheral lymph nodes in 2024 at Lighthouse clinics Malawi[@]

	Total (n=53)+	**Hematological malignancy (n=22)#**	**Other diagnosis (n=19)***	**P&**
Gender (male)	31 (59%; 45-72)	11 (50%; 29-71)	12 (63%; 41-85)	0.40
Age (yrs)	39 [24–49]	40 [25-53]	34 [25-44]	0.59
HIV status (positive)	44/46 (96%; 90-100)	19/20 (95%; 85-100)	15/16 (94%; 82-100)	0.87
• On ART	35/44 (79%; 67-92)	14/16 (87%; 71-100)	14/15 (93%; 80-100)	0.59
• CD4 (cells/μl)	255 [111-401]	238 [125-469]	266 [201-332]	0.91
Clinical symptoms				
• Fever	25/46 (54%; 40-69)	9/20 (45%; 23-67)	11/16 (69%; 46-92)	0.09
• Night sweats	21/46 (46%; 31-60)	10/20 (50%; 28-72)	9/16 (56%; 31-81)	0.71
• Loss of weight	24/46 (52%; 37-67)	9/20 (45%; 23-67)	11/16 (69%; 46-92)	0.16
• Cough	21/46 (46%; 31-60)	9/20 (45%; 23-67)	9/16 (56%; 31-81)	0.51
Full blood count				
• WBC (x1000 cells/ml)	8.3 [4.2-10.4]	9.0 [4.2-13.3]	8.4 [5.4-9.7]	0.91
• Hb (g/dl)	8.8 [5.1-9.8]	7.7 [5.1-10.2]	8.9 [8.8-9.1]	0.96
• Plt (x1000/ ml)	162 [65-258]	169 [86-232]	163 [150-299]	0.38
Ultrasound findings				
• Pericardial effusion	6/39 (15%; 4-27)	3/16 (19%; 0-38)	3/15 (20%; 0-41)	0.93
• Pleural effusion	6/39 (15%; 4-27)	3/16 (19%; 0-38)	2/15 (13%; 0-31)	0.69
• Ascites	7/39 (18%, 6-30)	2/16 (12%; 0-30)	4/15 (27%; 4-49)	0.33
• Any effusion	14/39 (36%; 20-51)	6/16 (37%; 13-62)	6/15 (40%; 15-65)	0.88
• Abdominal LN[x]	17/39 (44%; 28-59)	6/16 (37%; 13-62)	8/15 (53%; 28-79)	0.38
• Spleen lesions[x]	11/39 (28%; 14-43)	8/16 (50%; 25-75)	2/15 (13%; 0-31)	**0.03**

@ For proportions percentages and (95% Confidence intervals), for continous variables median and [IQR] are provided. Varying denominators due to missing data points; + including 12 without final diagnosis: lesion not represented 7, poorly preserved sample 3, small sample 1, lost sample/result 1; # Non-Hodgkin lymphoma n=19, Hodgkin lymphoma =2, multicentric Castleman disease=1; * reactive LN n=6, Kaposi's sarcoma n=5, carcinoma n=4, infection n=4; & X^2-Test for proportions, Kruskal-Wallace test for continuous variables; X enlarged abdominal lymph nodes and hypoechoic spleen lesions detectable by ultrasound

Non-tuberculous mycobacteria

In one patient, the presumptive diagnosis of disseminated NTM was made, although mycobacteriological culture and differentiation were unavailable for confirmation. The diagnosis was based on the histological pattern of a display of sheets of foamy macrophages in the H&E stain (Figure 3a) suggesting atypical mycobacterial infection. The ZN stain confirmed the presence of acid-fast rods (Figure 3b) and a repeat FNA aspiration yielded a negative Xpert MTB/RIF-Ultra result. The patient was treated for presumed *M.-avium-complex (MAC)* infection using azithromycin, rifampicin and ethambutol combined initially for 6 weeks with levofloxacin and clinically improved.

Clinical symptoms

The four cardinal WHO screening symptoms for TB (fever, night sweats, loss of weight and cough) were

each seen in approximately half of patients. In nine (20%; 95%CI 8-31) all four symptoms were present. There was no significant difference in frequency of symptoms between hematological malignancies and other diagnoses.

Laboratory results

Full blood count results were documented for 43 (81%). Significant leucocytosis (>15.000 cells/ml) was seen in only three patients and all had hematological malignancies (2 NHL, 1 HL). No neutropenia was detected. Anemia was frequent with a median hemoglobin of 8.8 g/dl. Thrombocytopenia <100.000/ml was mainly seen in hematological malignancies, but also in patients with Kaposi's Sarcoma and in those with reactive lymph nodes. The lowest platelet level observed was 23.000/ml in a patient with chronic lymphocytic leukemia/small lymphocytic lymphoma. There were no bleeding complications in this patient despite the thrombocytopenia. There were no statistically significant differences noted between patients with hematological malignancies versus other diagnoses (Table 1).

Abdominal ultrasound findings

Abdominal ultrasound results were available for 39 patients (74%); findings are summarized in Tab. 1. The proportion of patients with missing ultrasounds were not significantly different in patients with hematological (n=6; 27%) and other diagnoses (n=4; 21%). Pericardial effusion was detected in six patients (15%), pleural effusions in six (15%) and ascites in seven (18%); 14 (36%) patients had an effusion in at least one of these anatomical sites. Frequencies of effusions did not differ between patients with hematological or other diagnoses. Abdominal lymph nodes were detected in 17 (44%); again, no statistically significant differences were seen between groups. Hypoechoic spleen lesions were visible in 11 (28%). These were significantly more frequent in patients with hemtological disease (n=8, 50%) than in the group with other diagnoses (n=2, 13%; p=0.03). Figure 2 shows the frequency of final diagnoses in patients with positive abdominal ultrasound findings highlighting the high proportion of hematological diagnoses in patients with spleen lesions. In two patients with Kaposi's Sarcoma, hyperechoic lesions in the spleen were detected, which have a clearly different sonographic appearance (Figure 4).

Discussion

We describe the successful and safe implementation of a routine diagnostic program for enlarged lymph nodes in a referral ART outpatient clinic in Malawi, using ultrasound-guided core-needle biopsy for histological assessment when initial Xpert-Ultra testing for MTB on lymph node FNAs was negative. In the first year of implementation, 53 samples were safely obtained and in 77% of them a conclusive histological diagnosis was reached. In a dedicated lymph node biopsy

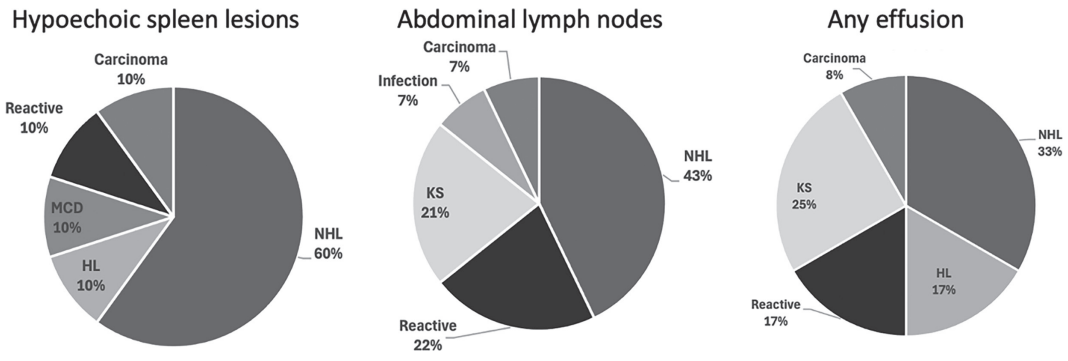

Figure 2. Frequency of histological diagnoses in peripheral lymph node biopsies in patients with pathological abdominal ultrasound findings.

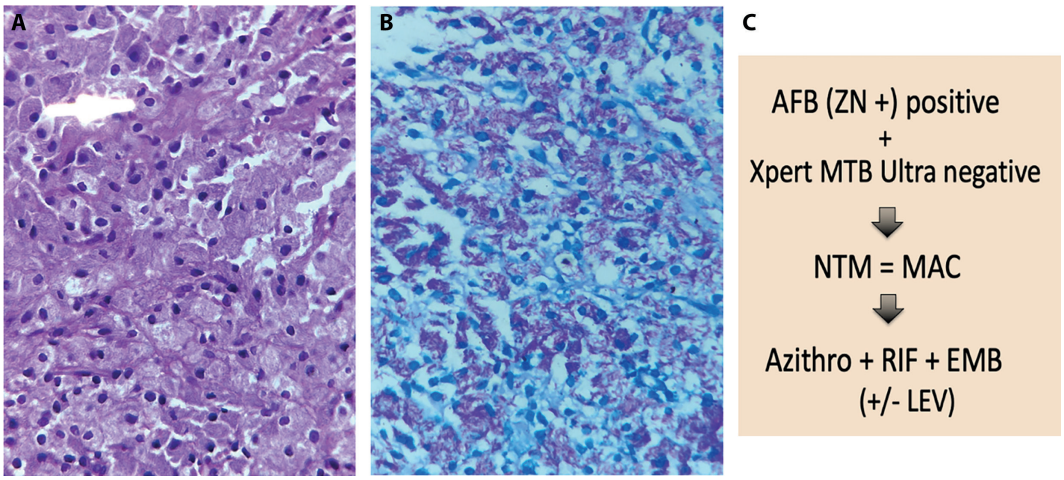

Figure 3. Presumptive diagnosis of disseminated Non-TB mycobaterial (NTM) infection (most likely M. avium-complex) with treatment implication: a) HE stain showing sheets of foamy macrophages, b) ZN stain confirming presence of acid-fast bacilli c) diagnostic logic for NTM with negative Xpert Ultra.

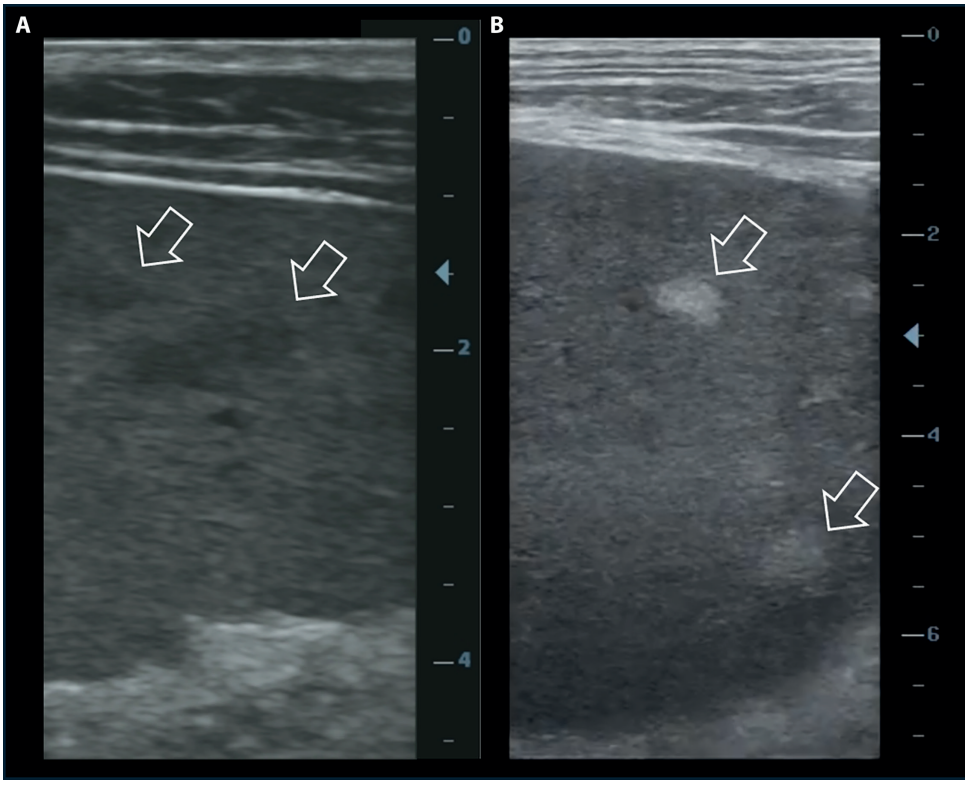

Figure 4. Sonographic appearance of focal lesions in the spleen. a) Hypoechoic lesions seen in disseminated lymphoma and TB(26); b) Hyperechoic, hemangioma-like lesions suggestive of disseminated Kaposi's Sarcoma(30).

clinic in a hematology unit in South Africa, the most frequent underlying cause was lymphadenopathy was TB with 34% (7,24). To limit the number of biopsies and histology examinations in our resource-limited environment, patients were initially investigated using an ultrasound-guided fine-needle aspirate (FNA) of the lymph node and only progressed for core-needle biopsy if Xpert-Ultra was negative. Xpert Ultra was shown to have sensitivity of 70% on lymph node FNA and a specificity of 100% in a South African setting (18,24); the positive predictive value was 100% making it a suitable test to reduce the number of core-needle biopsies as cases of TB lymphadenitis could readily be diagnosed and treated. In our cohort, only three cases (7%) were possibly attributable to TB; this low proportion being likely due to the pre-screening with FNA. More than half of the samples (54%) in our cohort yielded a hematological malignancy, mainly NHL, allowing referral to oncology services for treatment. In a previously reported lymph node biopsy cohort from South Africa, lymphoma was found in 27% of patients overall, or in 42% (75/177) when TB had been excluded (as a comparator to this cohort) (7). In this South African cohort it was also reported that three core-needle cylinders provided sufficient material to allow the diagnosis of lymphoma in 96% of patients (7). Only 1/53 (2%) of our samples were not diagnostically assessable due to too little material and our pathologists overall confirmed the observation that in most cases, a diagnosis is possible from core-needle cylinders. Training of ART clinicians to perform ultrasound-guided LN biopsies in short training courses was feasible, although the fact that in 7/53 (13%) of the samples the material was not considered representative may indicate that the target was missed in a minority. It is, however, important to note that Lighthouse clinical officers use ultrasound routinely in the work-up of patients with advanced HIV and they were thus generally acquainted with ultrasound technique; additional training is likely needed for those less well acquainted with ultrasound techniques. An interesting finding was one presumed diagnosis of disseminated NTM in a setting where mycobacterial culture facilities do not exist, due to reliance and pragmatic use of the high sensitivity of Xpert-Ultra in acid-fast stain positive samples and its specificity for MTB. In a histologically suggestive sample containing foamy macrophages, a Ziehl-Neelsen stain confirmed the ample presence of acid-fast mycobacteria, but as no MTB was detected, we assumed mycobacteria other than TB as the cause. This approach has previously been suggested for sputum samples (25) but to our knowledge has not been described in LN. EPTB and disseminated TB are common diseases and have high mortality, especially in PWH. Due to difficulties in diagnosis, patients with HIV are often started on empirical TB treatment based on the local prevalence, the clinical presentation and on tests that support the diagnosis, but don't confirm MTB microbiologically. One test frequently used to support a TB diagnosis is abdominal ultrasound for features compatible with disseminated TB – in particular effusions, enlarged lymph nodes and hypoechoic splenic lesions as described in the FASH protocol (19). Multiple studies have assessed the diagnostic value of ultrasound: a meta-analysis including more than 1,500 patients with HIV showed that sensitivity of the signs is poor while specificity is better (26). Pooled specificity was 89% for enlarged lymph nodes (ten studies) and 93% for hypoechoic spleen lesions (eight studies) – which is not ideal and other diagnoses should always be considered, especially if patients do not improve on TB treatment. Lymphoma is one well known cause for abdominal lymph nodes and hypoechoic infiltrations in the spleen (27). In our cohort, who already had a negative Xpert-Ultra on LN FNA, we frequently identified diagnoses other than TB associated with the abdominal ultrasound findings (Figure 3). A retrospective case series from a hematology department in South Africa showed that both abdominal lymph nodes (7/11 patients, 64%) and hypoechoic spleen lesions (7/11, 64%) are more frequent in lymphoma patients than in TB patients (enlarged LN 2/11, 18%; hypoechoic spleen lesions 5/11, 45%) (28). Due to overall higher prevalence and thus the higher pretest probability for TB, TB is still the more likely explanatory diagnosis of the ultrasound pathology seen in our settings. Nevertheless, both our findings and in the South African study underline that a definitive diagnosis by microbiology or histology should be attempted whenever feasible. Clinical diagnosis of TB is a common approach but it is known to be associated with higher mortality risk than bacteriologically confirmed TB (29).

This suggests that other, undiagnosed conditions which are not being adequately treated may add to the mortality. If enlarged superficial lymph nodes are present, biopsy can help to reach the definitive diagnosis.

Limitations

Our study has limitations as it was done at one center and the overall number of biopsies was not large. We only included patients that required a core-needle biopsy for their diagnosis and thereby did not capture data on the patients with positive Xpert-Ultra on LN FNA or those with other confirmatory tests of TB/other diagnoses, so we can neither comment on the overall prevalence of TB lymphadenitis nor on the effectiveness to be screened out by FNA. We observed that some patients were not reached by the time the histological result was obtained (with a turn-around-time that could be up to 3-4 weeks) – and some had died in the meantime. The management outcomes were not a focus of the current study, but rather that of the diagnosis and ultrasound protocol, however these gaps in treatment highlight the importance and urgency with which these diagnoses need to be made. More systematic clinical studies and better and more scalable, ideally point-of-care diagnostic tests are required to develop the most accurate and rapid diagnostic methods possible. Studies including all patients with lymphadenopathy may help us to predict *a priori* diagnoses more accurately, based on clinical characteristics and data available at the point of care.

Conclusions

Our study shows that ultrasound-guided CNB of enlarged peripheral lymph nodes can be successfully and safely integrated into routine care in referral ART clinics. After a negative Xpert-Ultra in FNA, the proportion of hematological and other malignancies was high. Abdominal ultrasound findings were frequently abnormal overall and hypoechoic spleen lesions were more common in patients with hematological abnormalities.

Ethics: This study used routinely collected clinical and programmatic data from patients under routine care conditions. Ethical approval for use of routine data for the evaluation was granted by the Malawi National Health Sciences Research Committee (NHSRC), protocol number NHSRC #2812. A waiver of informed consent was granted by the committee for the abstraction and use of this routinely collected program data under the blanket protocol. The waiver was requested in accordance with US federal regulations (OHRP-45CFR46.116(d)) that outline that the evaluation will not adversely affect the welfare and rights of the subject and is in retrospect in nature. As such it involves no more than minimal risk to the subject.

Author Contributions: T.K.: Biopsies, Data collection; Formal analysis; Writing – review & editing. V.P.: Biopsies, Data collection; Writing – review & editing. K.R.: Biopsies; Writing – review & editing. B.S.: Writing – original draft; Writing – review & editing. T.T.: Pathology assessment; Writing – review & editing. Y.F.: Pathology assessment; Writing – review & editing. M.P.: Supervision; Writing – review & editing. E.R.: Project administration; Resources; Supervision; Writing – review & editing. C.W.: Training; Formal analysis; Validation; Writing – review & editing. T.H.: Conceptualization and training; Formal analysis; Visualization; Writing – original draft; Writing – review & editing.

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Competing Interests: The authors declare that they have no competing interests.

Availability of Data and Materials: Data related to this article is available upon official request to the Lighthouse Trust managment.

Supplementary Material

Supplementary material 1: Training presentation (in pdf format, complete material including video clips can be obtained from the senior author upon request (theller@lighthouse.org.mw)).

Supplementary material 2: Biopsy phantom preparation for hands-on trainings.

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