

Efficacy of an Intensive, Ultrasound-Guided Fine-Needle Aspiration Biopsy Training Workshop in Tanzania

abstract

Background Fine-needle aspiration biopsy (FNAB) is a minimally invasive, cost-effective diagnostic tool that can be used in low-resource settings. However, adequacy and accuracy of FNAB is highly dependent on the skills of the operator and requires specialized training. Poor technique can preclude definitive diagnoses because of insufficient quality or quantity of FNAB samples. We evaluated the efficacy of an intensive training experience in Tanzania on improving ultrasound-guided FNAB techniques.

Methods A 2-day workshop offered didactic lectures, demonstrations, and hands-on practicum on fundamentals of ultrasound imaging and FNAB technique. A prospective interventional study design was used with pre- and postintervention surveys and assessments to measure the effect of the workshop on specific skills related to slide smearing and ultrasound-guidance among participants.

Results Twenty-six pathologists and radiologists, including trainees in each specialty, participated in the workshop. Pre- and postworkshop assessments demonstrated that most participants improved significantly in nearly all technical skills for slide smearing and ultrasound-guided FNAB. After the workshop, most participants demonstrated substantial improvements in ability to prepare the ultrasound equipment, measure the lesion in three dimensions by ultrasound, target lesions in one pass using both parallel and perpendicular approaches, and prepare high-quality aspirate smears.

Conclusion An in-country 2-day workshop in Tanzania was efficacious in transferring basic skills in FNAB smear preparation and ultrasound-guided FNAB, resulting in skills enhancement among participating pathologists and radiologists. Although mastery of skills was not the goal of this short workshop, participants demonstrated proficiency in most technical elements after workshop completion, and the workshop generated interest among select participants to pursue additional intensive training in cytopathology.

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BACKGROUND

Africa is facing an unprecedented growth in cancer burden and is inadequately prepared to meet this public health challenge. By 2030, 1.27 million new cancer cases per year are expected, with 0.97 million expected deaths.¹ Although there is no population-based cancer registry in Tanzania to provide reliable data on the country's cancer burden, Tanzania estimates that it will see approximately 44,000 new patients with cancer per year.² Currently, demands for cancer care far exceed available services, and the number of new cases is steadily increasing, doubling between 2006 and 2013 alone. Within Tanzania's hierarchical health care structure, the vast

majority of specialized cancer care, including pathology, is concentrated in the national referral hospital and a few select zonal hospitals.^{3,4}

Muhimbili National Hospital (MNH) is the largest national referral hospital and the public teaching hospital affiliated with Muhimbili University of Health and Allied Sciences (MUHAS) in Tanzania and receives approximately 10,000 surgical specimens and 7,000 cytology specimens per year. MUHAS, in collaboration with MNH, houses Tanzania's only pathology residency program and the largest of only three radiology residency programs in the country. Most suspected cancer cases in Tanzania are referred to the Central Pathology Laboratory at MNH for pathologic confirmation before any referral for cancer

treatment can be initiated. Many patients travel long distances for basic diagnostic procedures, and the Central Pathology Laboratory at MNH faces an extraordinarily high volume of cases, resulting in diagnostic delays that may contribute, in part, to advanced disease at the time of cancer diagnosis.

Fine-needle aspiration biopsy (FNAB) is a rapid, minimally invasive, and cost-effective diagnostic method that requires minimal equipment and laboratory infrastructure. FNAB can be performed at the bedside and is practical even in rural clinics in low-resource settings for morphologic assessment as well as triaging the sample for ancillary testing.⁵⁻⁸ The addition of ultrasound-guidance to FNAB enables direct visualization of the targeted lesions and ensures more accurate sampling. Ultrasound also enables FNAB of deeper lesions that cannot be well palpated, expanding the range of lesions that can be biopsied. A major limitation of FNAB is that diagnostic accuracy is contingent on formal training in sampling technique and highly dependent on skills of the operator.⁹ The overall goal for sampling and slide preparation technique is to obtain a smear with adequate quantity and quality of well-preserved cells, which are representative of the target lesion.¹⁰

Effective implementation of FNAB is limited by the lack of personnel who are proficient in this technique.¹⁰ MNH has an established FNAB Clinic in which pathology residents perform biopsies of palpable masses under the supervision of pathologists. Ultrasound-guided and computed tomography-guided FNABs are also performed in tandem by pathologists and radiologists. However, there is no formal curriculum for teaching this technique, and the training that residents receive in palpation-guided and radiology-guided FNAB is highly variable. We conducted an in-country intensive workshop with pre- and

postworkshop evaluations to measure the efficacy of an intensive training experience in improving ultrasound-guided FNAB techniques among radiologists and pathologists in Tanzania.

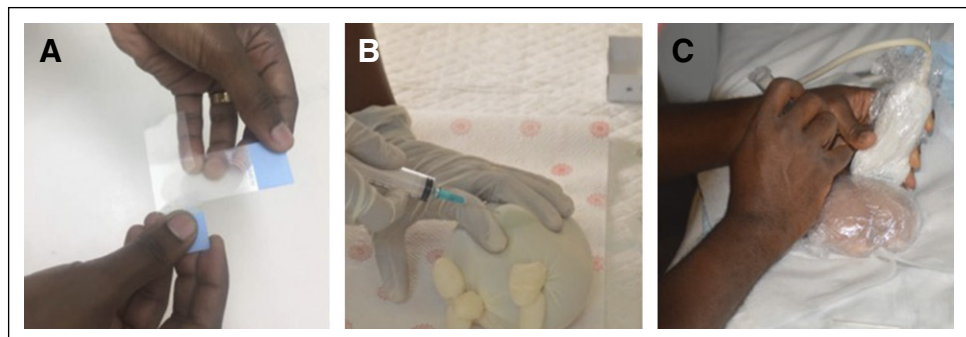
METHODS

Training Program

MNH, MUHAS, and the University of California, San Francisco (UCSF) jointly hosted a workshop in ultrasound-guided FNAB in Dar es Salaam, Tanzania, in September 2017. Radiologists, pathologists, and residents from MUHAS, MNH, and select zonal hospitals in Tanzania were invited to participate in a 2-day intensive course. All attendees, including trainees, participated in the course voluntarily.

The training program was designed and implemented by two cytopathologists (D.L.N., R.B.) and two radiologists (S.S., A.L.) from UCSF, as well as a pathologist from MUHAS (E.V.). The course consisted of didactic lectures on fundamentals of ultrasound imaging and cytopathology, followed by demonstrations and hands-on practicum. For the slide-smearing sessions, glass slides and moisturizing lotion were used to instruct course participants on optimal smearing technique (Fig 1A). The hands-on training for ultrasound-guided FNAB was performed on phantom models that were prepared from chicken breast and gelatin blocks embedded with olives to serve as target lesions (Fig 1B). For FNAB sampling practice, 10-mL slip-tip syringes and 23G 1-1/2-inch needles were used (Fig 1C). Ultrasound machines with standard broadband linear array transducers were provided by the MNH Radiology Department.

Fig 1. (A) Slide-smearing technique was taught using moisturizing lotion and glass slides. (B) Phantom models were prepared from blocks of chicken breast or gelatin with embedded olives as target lesions. (C) Hands-on practical training used ultrasound-guidance for fine-needle aspiration biopsy of a target olive.



Study Design and Data Collection

A prospective interventional study design was used with administration of pre- and postintervention assessments to measure the impact of the workshop on specific skills related to slide smearing and ultrasound-guided FNAB. The study was exempted from reviews by the UCSF Committee for Human Research (no. 17-23105) and the MUHAS Institutional Review Board. All course registrants received written material describing the methods and goals of the study. After a verbal introduction of the study by the Tanzanian leader of the course (E.V.), study participants provided verbal informed consent before the start of the course.

The workshop surveys and practical assessments were developed jointly by the workshop instructors (D.L.N., A.L., R.B.), a pathologist from MUHAS (E.V.), and a pathologist with expertise in medical education (K.L.W.). On day 1, a preworkshop survey was administered to collect demographic information and data on prior training, experience, and confidence with ultrasound-guided FNAB techniques and slide smearing. The survey included questions to assess participants' self-reported comfort level in performing FNAB by palpation and with ultrasound guidance and smear preparation (on a scale of 1 to 5, with 1 indicating uncomfortable and 5 indicating very comfortable).

Skill assessments included two categories, analyzing the participant's ability to (1) prepare a direct smear using FNAB material and (2) perform an ultrasound-guided FNAB using both perpendicular and parallel approaches. Direct smear preparation was assessed with three overall measures: (1) placement of an appropriate amount of material, (2) successful division of sample, and (3) successful creation of an oval smear. Performance of an ultrasound-guided FNAB was assessed with five overall measures: (1) preparation of the ultrasound equipment, (2) identification of the lesion, (3) measurement in three dimensions, (4) targeting the lesion using the parallel approach, and (5) targeting the lesion using the perpendicular approach. Competencies in specific technical skills pertaining to preparation of a smear ($n = 10$; Table 1) and performance of an ultrasound-guided FNAB ($n = 11$; Table 2) were graded as binary variables. In Table 2, the postworkshop column is further divided to create a 2×2 table to report the

number of participants who attained, retained, lost, or did not gain a skill.

Practical assessments of slide-smearing skills were administered by the two cytopathologist-course instructors; practical assessments of ultrasound-guided FNAB skills were administered by all four course instructors. The postworkshop assessment for ultrasound-guided FNAB was administered at the end of day 1; the postworkshop assessment for smearing technique was administered on day 2. Pre- and postworkshop scores were not disclosed to participants; however, individualized feedback was provided to each participant after completion of the postworkshop assessments and surveys.

Statistical Analyses

Pre- and postworkshop differences in quantitative variables were compared by Wilcoxon signed-rank test. Binary response variables were assessed by the McNemar test. Statistical significance was declared based on a P value $< .05$, and no multiple testing adjustments were conducted. All the statistical analyses were performed using the statistical computing software R (<https://www.r-project.org>).

RESULTS

All 26 course attendees provided informed consent and participated in at least one aspect of the study. The prior clinical experiences of the course participants are summarized in Table 3. The majority of participants were trainees (69%), and the overall median years of experience, including residency training, was 2 years (range, 1 to 11 years). Fewer than half of participants reported any prior training in palpation-guided FNAB (39%) or ultrasound-guided FNAB (39%), and the median number of palpation-guided FNABs performed per month was 0 (range, 0 to 78).

Of the 26 course attendees, 22 completed the precourse survey, and 21 completed the postcourse survey. Overall, a total of 21 participants completed both. The median score for participants' self-reported assessment of comfort with use of ultrasound to identify lesions for FNAB was 3 (interquartile range [IQR], 2 to 4) before the workshop and 4 (IQR, 4 to 5) after the workshop ($P = .006$). Participants' median self-reported assessment of comfort with performing

Table 1. Comparison of Pre- and Postworkshop Technical Skills for Slide-Smearing Technique

Technical Skill	Preworkshop (n = 26)	Postworkshop (n = 23)*		P
		No	Yes	
Appropriate smear thickness				.003
No	21 (81)	5 (28)	13 (72)	
Yes	5 (19)	1 (25)	3 (75)	
Appropriate amount of material applied (not too abundant)				.006
No	18 (69)	3 (20)	12 (80)	
Yes	8 (31)	1 (14)	6 (86)	
Satisfactory smear shape				.003
No	17 (65)	3 (21)	11 (79)	
Yes	9 (35)	0 (0)	8 (100)	
Crush artifact				.134
No	6 (23)	0 (0)	4 (100)	
Yes	20 (77)	0 (0)	18 (100)	
Scrape artifact				1.000
No	14 (54)	5 (42)	7 (58)	
Yes	12 (465)	6 (55)	5 (45)	
Pop-off artifact				.617
No	2 (8)	1 (50)	1 (50)	
Yes	24 (92)	3 (15)	17 (85)	
Sufficient material applied (not too scant)				1.000
No	1 (4)	0 (0)	1 (100)	
Yes	25 (96)	0 (0)	21 (100)	
Satisfactory position of hands				.002
No	21 (81)	5 (26)	14 (74)	
Yes	5 (19)	1 (25)	3 (75)	
Satisfactory position of slides				< .001
No	22 (85)	2 (11)	17 (89)	
Yes	4 (15)	1 (33)	2 (67)	
Satisfactory speed				.008
No	9 (35)	7 (100)	0 (0)	
Yes	17 (65)	9 (60)	6 (40)	

NOTE. Data are given as No. (%) unless otherwise indicated.

*Total number may sum to < 23 if a specific skill was omitted from the postworkshop assessment by participants.

ultrasound-guided FNAB before the workshop was 3.00 (IQR, 2.00 to 3.75). Median self-reported assessment of comfort after the workshop was 4 ($P = .007$), with 17 of 21 participants (81%) reporting feeling comfortable or very comfortable after the workshop versus 6 of 22 (27%) reporting comfort before the workshop. Among nine participants who did not feel comfortable (score, 1 to 2) before the workshop, seven reported feeling comfortable after the workshop (score, 4 to 5).

Twenty-five people participated in the preworkshop slide-smearing assessment, 23 participated

in the postworkshop assessment, and 22 participated in both the pre- and postworkshop assessments. Table 4 provides a comparison of preworkshop and postworkshop assessments of competency in FNAB smear preparation. There were statistically significant improvements in all primary areas of competency after the workshop, including ability to place an optimal amount of material on a slide ($P < .001$), divide a sample satisfactorily ($P < .001$), and create a satisfactory smear ($P < .001$). Participants were evaluated on 10 technical skills for slide-smearing technique before and after the workshop; the

Table 2. Comparison of Pre- and Postworkshop Technical Skills for Ultrasound-Guided FNA

Technical Skill	Preworkshop (n = 23)	Postworkshop* (n = 21)		P
		No	Yes	
Satisfactory position of hands				.013
No	15 (65)	5 (38)	8 (62)	
Yes	8 (35)	0 (0)	7 (100)	
Satisfactory position of transducer				.001
No	17 (74)	3 (20)	12 (80)	
Yes	6 (26)	0 (0)	5 (100)	
Satisfactory position of lesion on screen				.013
No	15 (65)	5 (38)	8 (62)	
Yes	8 (35)	0 (0)	7 (100)	
Placed needle in appropriate amount of time				.070
No	17 (74)	6 (46)	9 (54)	
Yes	6 (26)	2 (40)	3 (60)	
Satisfactory repositioning of needle				.004
No	18 (28)	5 (33)	10 (67)	
Yes	5 (72)	0 (0)	5 (100)	
Performed adequate excursions				< .001
No	19 (83)	2 (13)	14 (87)	
Yes	4 (17)	0 (0)	4 (100)	
Visualized lesion in maximum dimension				.008
No	13 (57)	2 (18)	9 (82)	
Yes	10 (43)	0 (0)	9 (100)	
Measured lesion in three dimensions				< .001
No	20 (87)	3 (18)	14 (82)	
Yes	3 (13)	0 (0)	3 (100)	
Visualized needle tip in lesion				< .001
No	22 (96)	3 (16)	16 (82)	
Yes	1 (4)	0 (0)	1 (100)	
Targeted sample with parallel method				.001
No	20 (87)	5 (29)	12 (71)	
Yes	3 (13)	0 (0)	3 (100)	
Targeted sample with perpendicular method				< .001
No	19 (83)	3 (19)	13 (81)	
Yes	4 (17)	0 (0)	4 (100)	

*Total number may sum to < 21 if a specific skill was omitted from the postworkshop assessment by participants.

results are summarized in [Table 1](#). During the precourse assessment, crush artifact ($P = .134$), pop-off artifact ($P = .617$), and application of insufficient material ($P = 1.0$) were not areas of deficiency for most participants. After the workshop, improvements in the smear shape ($P = .003$), positioning of hands ($P = .002$), and positioning of slides ($P < .001$) were significant. A regression in the number of participants who smeared quickly enough was noted (65% before the training *v* 27% after the training; $P = .008$).

Ultrasound-guided FNAB technique was assessed separately. Twenty-three individuals participated in the preworkshop assessment, 21 participated in the postworkshop assessment, and 20 participated in both components. For the five primary measures of competency in ultrasound-guided FNAB, summarized in [Table 5](#), there was statistically significant improvement in all skills except for an ability to identify a targetable lesion ($P = .134$), because most participants were able to successfully identify the lesion before the

Table 3. Prior Clinical Experiences of Course Participants (N = 26)

Experience	No. (%)*
Years of experience, including residency, median (range), No.	2 (1 to 11)
Clinical specialty	
Pathology	13 (50)
First-year residents	6 (26)
Second-year residents	3 (12)
Faculty	2 (8)
No response	2 (8)
Radiology	9 (35)
Second-year residents	3 (12)
Third-year residents	3 (12)
Faculty	2 (8)
No response	1 (4)
Not reported	4 (15)
Practice setting	
National referral hospital	10 (38)
Zonal hospital only	1 (4)
Regional hospital only	3 (12)
Private practice only	1 (4)
Mix of national referral hospital and other	6 (24)
No response	5 (19)
Prior training for palpation-guided FNA	
None	12 (46)
Residency	6 (23)
Workshops	2 (8)
Residency and workshops	2 (8)
No response	4 (15)
Prior training received for US-guided FNA	
None	12 (46)
Residency	7 (27)
Workshops	3 (12)
No response	4 (15)

Abbreviations: FNA, fine-needle aspiration; US, ultrasound.
*Unless otherwise indicated.

tutorial. Participants were evaluated on 11 technical skills for ultrasound-guided FNAB before and after the workshop; the results are summarized in Table 2. Participants demonstrated improvement in all areas except for ability to place the needle in the lesion in a satisfactory time ($P = .07$).

DISCUSSION

Training and advocacy for enhanced pathology services are critically needed in sub-Saharan

Africa.¹¹ Although FNAB offers advantages as a rapid, minimally invasive, and cost-effective diagnostic method, the effective implementation of FNAB is limited by the lack of skilled personnel.¹⁰ The results of this in-country training workshop conducted in Tanzania demonstrated that participants improved significantly in nearly all relevant technical skills as the result of hands-on training from expert instructors during an intensive 2-day workshop. The significant reduction in the proportion of participants who prepared smears with satisfactory speed before and after the workshop likely is due to the performance of new and unfamiliar skills and is unlikely due to true regressions in technical skills among participants. Certainly, this 2-day training workshop alone will not suffice to render competency in all technical skills related to smear preparation and ultrasound-guided FNAB; however, it demonstrated the feasibility of skills transfer using the format of a structured workshop with a hands-on practicum using simulation models. Moreover, the high level of participation and interest in the course provided an indicator of the enthusiasm for acquisition of knowledge and skills to be able to perform FNAB in Tanzania.

A critical component to addressing shortcomings in pathology services in low- to middle-income countries is increasing access to high-quality training opportunities, which include not only formal residency programs but also focused tutorials.^{7,12} Diagnostic accuracy improves with formal training, reducing nondiagnostic rates and the need for excisional biopsies.^{6,8-10} In one study, physicians who had previously received formal training in FNAB (defined as individuals who had completed training with ≥ 150 FNABs under the supervision of an experienced practitioner), missed only 2% of breast cancers because of interpretative error, and no cases were missed because of sampling error, defined as either a nondiagnostic or a nonrepresentative specimen. In contrast, physicians with no training missed 25% of breast cancers, which was almost entirely attributable to sampling error. In addition, specimens obtained by physicians with formal training were more cellular and were less likely to be nondiagnostic.⁹ Despite the well-described correlation between FNAB diagnostic accuracy and training, one survey of the state of FNAB in Nigeria showed that in up to 60% of institutions, pathologists and technologists in charge of FNAB had no formal training

Table 4. Assessment of Competency in Fine-Needle Aspiration Smear Preparation

Competency	Preworkshop (n = 25)		Postworkshop (n = 23)		P
	No	Yes	No	Yes	
Placed appropriate amount of material on slide	21 (84)	4 (16)	1 (4)	22 (96)	< .001
Divided sample successfully	20 (80)	5 (20)	7 (30)	16 (70)	< .001
Created smear successfully	22 (88)	3 (12)	5 (22)	18 (78)	< .001

in cytology. Only a small subset of individuals (10%) had previously received training through short-term fellowships at foreign institutions, whereas the remainder learned the technique through self-instruction.¹³

The lack of formal training is likely a manifestation of the severe shortage of pathologists in sub-Saharan Africa, with very few pathologists specializing in cytopathology and even fewer trained cytotechnologists.^{14,15} A survey of a pathology laboratory in Tanzania found that the concordance between the diagnoses rendered by an Italian pathologist and the diagnoses rendered by the Tanzanian laboratory in a set of body fluid and FNAB specimens was 57%; the concordance for cervical smears was 75%.¹⁶ More importantly, none of the cytologic slides was considered technically satisfactory by the Italian pathologist, because of poor staining, inappropriate thickness of the smears, or nonrepresentative sampling. The combination of cytology and FNAB can be a powerful diagnostic tool and an essential component of any cancer care system; however, poor quality secondary to inadequate training may result in the false impression that it is a suboptimal diagnostic modality.

There are several limitations to this study which should be acknowledged. First, this analysis is based on a small sample, and not all participants completed all components of the pre- and postworkshop surveys and assessments. Of 26

total participants, 20 completed the pre- and postworkshop ultrasound-guided-FNAB assessment, 22 completed the pre- and postworkshop slide-smearing assessment, and 21 completed the pre- and postcourse survey. Although the surveys were designed in collaboration with Tanzanian facilitators and clear instructions were verbally provided by a Tanzanian leader, cultural differences in how the participants interpreted and responded to survey questions and self-assessments may have been present. In addition, there may have also been variation in how the instructors made assessments; however, the assessment metrics and quality expectations were standardized across the instructors before the workshop. All techniques were performed on simulation models rather than on real patients, and transferability of skills to a real-life clinical setting was not assessed. Finally, the workshop was a 2-day training course and provided only an introduction to basic skills and concepts, with the expectation that this short course would be insufficient for mastery of skills and would need to be followed with additional training and opportunities for repetition of acquired skills. Retention of skills beyond the duration of the course was not measured.

This pilot study demonstrated that an intensive 2-day training workshop provided efficacious in-country training for pathologists and radiologists in Tanzania, resulting in skills enhancements in ultrasound-guided FNAB. Even among trainees

Table 5. Assessment of Competency With Ultrasound-Guided FNA Technique

Competency	Preworkshop (n = 23)		Postworkshop (n = 21)		P
	No	Yes	No	Yes	
Prepared the ultrasound equipment appropriately	19 (83)	4 (17)	1 (5)	20 (95)	< .001
Successfully identified lesion	7 (30)	16 (70)	1 (5)	20 (95)	.134
Measure the lesion in three dimensions	20 (87)	3 (13)	5 (24)	16 (76)	.001
Target the lesion in one pass using the parallel approach	19 (83)	4 (17)	4 (19)	17(81)	.001
Target the lesion in one pass using the perpendicular approach	19 (83)	4 (17)	3 (14)	18 (86)	< .001

with minimal prior experience, most were able to perform appropriate slide-smearing techniques at completion of the workshop. This practical workshop on ultrasound-guided FNAB improved participants' skills in cytopathology and also ignited interest in this diagnostic modality. Although mastery of skills was not the goal of this short workshop, participants became familiar with the techniques and several trainees have sought additional opportunities for more intensive training, including observerships at UCSF. In the future, we aim to leverage our collaboration to provide ongoing training opportunities for individuals with interest in developing

cytopathology expertise, using a "training the trainers" model, to continue to increase the availability and efficacy of FNAB in Tanzania and comparable low-resource settings. As an example, two current pathology residents at MUHAS who have received additional intensive training in FNAB will colead the follow-up workshop as teaching assistants. Skills transfer through longitudinal collaboration and partnership will allow for evaluation of long-term impact.

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