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Ultrasound-Guided Fine Needle Aspiration of Thyroid Nodules: A Consensus Statement by the Korean Society of Thyroid Radiology

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Ultrasound (US)-guided fine needle aspiration (US-FNA) has played a crucial role in managing patients with thyroid nodules, owing to its safety and accuracy. However, even with US guidance, nondiagnostic sampling and infrequent complications still occur after FNA. Accordingly, the Task Force on US-FNA of the Korean Society of Thyroid Radiology has provided consensus recommendations for the US-FNA technique and related issues to improve diagnostic yield. These detailed procedures are based on a comprehensive analysis of the current literature and from the consensus of experts.

Index terms: *Thyroid; US; Fine needle aspiration biopsy; Technique*

INTRODUCTION

Thyroid nodules are commonly encountered in clinical practice. Due to the excellent resolution provided by high-frequency ultrasound (US) devices, thyroid nodules as small as 2–3 mm can be detected and the prevalence of thyroid nodules has increased to 68%, according to a recent study (1-3). Considering that approximately 5–15% of detected nodules will eventually be verified as malignant through surgery (4, 5), all guidelines recommend US-guided fine-needle aspiration (US-FNA) to distinguish malignant from benign thyroid nodules, and the results substantially affect the management of thyroid nodules (1, 4-9). Compared to palpation-guided FNA, the routine use of US guidance has significantly reduced the rates of nondiagnostic sampling and false-negative aspirates due to selective targeting of specific nodules, leading to an overall decline in the number of unnecessary surgeries performed for benign thyroid nodules and a concurrent increase in thyroid cancer yield in thyroidectomy specimens (4, 10, 11).

However, the success of US-FNA strongly depends on the experience of the operator and cytopathologist, as well as the intrinsic characteristics of the nodule. Therefore, about 0.4–40.7% of FNA results are insufficient for diagnosis and procedure-related complications still occur, albeit infrequently (12-25). In addition, performing repeated

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FNAs potentially increases medical costs and the patient's discomfort (26).

Accordingly, The Korean Society of Thyroid Radiology (KSThR) organized a task force comprised of radiologists with 10–20 years of experience in US-FNA of thyroid nodules to develop a consensus statement for the procedure. To retrieve relevant articles on the procedural aspects of US-FNA, a PubMed search was conducted through 2014 using the following search terms: thyroid nodule, thyroid malignancy, US, and fine-needle aspiration (FNA) biopsy. Based on the subsequent literature review and expert consensus of KSThR, this document will cover the technical aspects and pre-/post management of US-FNA of the thyroid nodule in detail, as well as the factors influencing cytologic adequacy.

Pre-Procedural Evalations: Informed Consent and Guidance for Patients with Bleeding Tendency

To provide optimal care for patients with thyroid nodules, interdisciplinary collaboration is essential among the health care specialists involved in US-based management of thyroid nodules, including the radiologist, cytopathologist, endocrinologist and surgeon. In addition, standardized reporting systems for US-based thyroid imaging and cytologic diagnosis, such as Thyroid Imaging Reporting and Data System and Bethesda system, are recommended to establish better stratification of cancer risk (6, 27).

Informed consent should be signed by the patient after discussing the purpose and procedure of FNA in detail using patient-friendly language so that the patient can fully understand the procedure (1, 7, 8). It should be emphasized that US-FNA is the most reliable and safest diagnostic method for thyroid nodules, however, serious FNA-related complications such as large hematoma that cause upper airway obstruction have occurred in a few patients (25, 28-30). In addition, it is recommended to explain to the patient that there is a small risk of collecting insufficient sample for diagnostic purposes and to explain other non-contributory results including the concepts of false-negatives and false-positives (7, 8).

Although a screening test for coagulation is not always needed, a thorough medical history to assess hemorrhagic risk factors, including disorders affecting the coagulation cascade (liver cirrhosis, end-stage renal disease, hematologic disease) and antithrombotic medications, should be obtained prior to the procedure (8, 31, 32). Antithrombotic agents, such as warfarin, heparin, aspirin, or clopidogrel bisulfate are frequently prescribed as prophylaxis in patients with coronary and cerebral vascular disease and in those at risk for thromboembolic phenomena.

Interruption of antithrombotic agents can minimize the risk of procedure-related bleeding, despite the association with major cardiovascular adverse events by returning to pre-therapy levels of thromboembolic risk (33). If the patient is taking warfarin, the referring physician should advise the patient to stop taking the medication for 5 days before the procedure, and FNA can be performed if the international normalized ratio is less than 1.5 to 1.7 (31). If the patient needs to remain in the antithrombotic state because of a medical condition, such as a heart condition, recent arterial stent placement, or vascular surgery (8, 31), another option is for the patient to stop the warfarin 2 days before the FNA and begin subcutaneous administration of enoxaparin every 12 hours (31). Warfarin may be restarted the day after the FNA, and the patient should continue to receive enoxaparin until the international normalized ratio returns to therapeutic levels (2–3 range) (8, 31). For the patients taking anti-platelet agents, like aspirin or clopidogrel bisulfate, the patient should refrain from taking the medications for 3–5 days before and 3 days after US-FNA, unless the patient needs to take the medication as indicated by the patient's referring physician (1, 8, 31).

A recent study of 593 patients who underwent US-FNA on 788 total neck lesions reported that two hematomas developed in 144 patients who were on daily antithrombotic medications, while four hematomas developed in the other 449 patients who were never on those types of medications. Therefore, incidences of bleeding-related complications were not significantly different between the two groups (34). This result indicated that discontinuing antithrombotic medications might not be crucial for preventing US-FNA related bleeding.

Therefore, the decision to stop taking antithrombotic agents to prevent bleeding in patients who will undergo US-FNA should be judged according to individual circumstances. Hence, close consultation with the referring physician is essential. However, if it is inevitable that US-FNA of thyroid nodule will be performed under conditions with bleeding tendency, an experienced operator must carefully perform US-FNA using smaller needles with a limited number of passes after informing the patient about the slightly increased risk of bleeding (8, 31). Additionally, under such circumstances, the medical team must maintain compression over the puncture site for a longer period than usual (31).

<Summary>

– Detailed investigation of bleeding tendency is recommended for patients with thyroid nodules prior to US-FNA, although a screening test for coagulation is not always needed.

– If US-FNA is performed for patients with bleeding tendency, an experienced operator should gently manipulate the needle, followed by a longer period of manual compression.

Technical Details of US-FNA of Thyroid Nodule

Local Anesthesia

Because most US-FNAs are well-tolerated and are not associated with significant patient pain or discomfort, routine use of local anesthesia has not been recommended (7, 9, 31, 32). However, some patients may complain of pain or discomfort, which can make the procedure less tolerable. Therefore, local anesthesia can be used to improve the patient's compliance (7, 9, 31, 32, 35). To alleviate patient's discomfort, approximately 1–2 mL of 1–2% lidocaine hydrochloride solution may be injected into the subcutaneous tissue over the thyroid capsule using a small caliber needle. Alternatively, topical lidocaine cream can be used to minimize children's distress (36). Regarding the benefit of local anesthesia during US-FNA, one study revealed that single needle puncture without local anesthesia did not cause significant pain, when compared to procedures with local anesthesia (37). So we recommend the use of local anesthetic agents for deep, non-palpable thyroid nodules that may require two or more needle punctures to obtain the specimen (7, 35, 37).

<Summary>

– Local anesthesia is not routinely recommended to prevent pain during US-FNA, but might be helpful for multiple needle punctures.

Aspiration Technique

Before performing US-FNA, the operator should verify the bleeding risk of the patient and previous cytologic results from medical records if available. The operator should sit in front of the screen of the US equipment, usually on the right side of patient for ease of handling. The FNA procedure is performed with the patient supine, with a pillow placed under the shoulders to facilitate neck extension and optimize visualization of the area, using a high-resolution 7.5–14 MHz linear-array transducer. According to US-based recommendations for thyroid nodules proposed by the KSThR (38) and the American Thyroid Association (4), the operator should preferentially select the thyroid nodule that shows at least one of the following malignant US findings: a taller-than-wide shape, a spiculated or microlobulated margin, marked hypoechogenicity, microcalcification, and/or macrocalcification. In contrast, US characteristics consistent with benignity include a pure cyst, a predominantly cystic or cystic nodule with reverberating artifacts and spongiform nodules (38, 39). In addition, color Dopper US can be used to reveal any blood vessels in and around the nodule so that vascular injury can be avoided during the procedure (1, 35).

After the patient's neck is antiseptically swabbed, FNA is subsequently performed with the needle oriented either parallel or perpendicular to the US probe (1, 9, 31, 32). When the needle tip is placed appropriately within the target nodule, tissue samples is collected with 6 to 7 "to-and fro" needle movements over 5–10 seconds, with 2–3 mL suction applied (35). Because the microscopic hemorrhage induced by negative pressure during FNA can hamper accurate cytologic interpretation, a repetitive back and forth motion of the needle without applying negative pressure, known as "capillary sampling", was proposed as an alternative method for obtaining less blood-contaminated specimens (9, 12, 17, 32). However, there have been concerns about the effectiveness of capillary sampling with regards to cellular adequacy. Some studies demonstrated that capillary sampling yields higher quality specimens with fewer bloody stains compared with FNA (12, 40), whereas others indicated that there was no significant difference between the two techniques (41-43). To achieve a better diagnostic yield, we recommend the "combined method": initial capillary sampling followed by negative pressure, depending on the cellularity of the FNA specimen (37). In this method, the operator moves the needle back and forth repeatedly without suction for a few seconds and sequentially applies a minimal amount of negative pressure if insufficient amount of aspirates is obtained.

Biopsy specimens should be obtained from different quadrants of the nodule to ensure a representative sample (1, 9). When an appropriate amount of material has filled the needle hub, the syringe-needle unit is rapidly withdrawn after releasing the suction (1, 9, 35). Releasing the suction before needle withdrawal forces the aspirated specimen into the needle, but not into the needle tract, which could prevent potential complications such as needle tract seeding (1, 9, 25).

<Summary>

– An operator selects the thyroid nodule to be aspirated, based on the US features of the thyroid nodule.

– To obtain sufficient amount of cells by minimizing bloody contamination, an operator begins US-FNA by capillary sampling with minimal negative pressure, then increases the amount of negative pressure depending on the US characteristics of the thyroid nodule.

Needle Size and Number of Needle Passes

To obtain a sufficient amount of specimen, the operator routinely uses a 2–10 mL plastic syringe attached to a conventional 23–25 gauge needle (1, 7, 9, 31, 32). A syringe holder may or may not be used, according to the preference of the operator. The number of needle passes, ranging from 2 to 3, for each thyroid nodule is determined depending on the US characteristics of the thyroid nodule and the operator's preference (32). To improve the cellular adequacy of FNA, several methods are recommended. For example, a gentler manipulating needle technique involving small needle size, capillary technique, and short needle dwell time, followed by manual compression would be effective for preventing bloody aspirates and procedure-related hematoma when targeting a hypervascular nodule (1, 9, 12, 40). For cystic or complex lesions, sampling could be done from the solid elements and from suspicious areas of complex lesions after drainage of the viscous colloid using a large needle (1, 7, 31). In addition, a larger needle and/or greater negative pressure might be helpful to obtain adequate specimens from hard nodules (1, 9, 31).

<Summary>

– The needle size or number of passes used in every setting of US-FNA would be determined depending on the US characteristics of the thyroid nodule and the operator's preference.

Parallel or Perpendicular Technique

In the parallel technique, the needle advances along the long axis of the probe and is visualized from the skin puncture to the thyroid nodule, allowing the operator to observe needle penetration, location of distal tip, and the entire pathway of the needle (31, 32). In the perpendicular technique, the nodule is positioned in the mid-portion of the screen and the point of needle insertion might be central, just over the nodule to be targeted (31, 32). The needle advances perpendicular to the probe footprint at an angle determined by the nodule's depth and only the tip of the needle is visualized when it enters the nodule. Therefore, the needle tip should be continuously monitored by US to prevent vascular, tracheal or esophageal injury during the entire duration of the FNA.

According to one study comparing parallel and perpendicular techniques with regard to specimen adequacy from thyroid nodules, the parallel technique significantly decreased the overall nondiagnostic sampling compared to the perpendicular technique (44). However the sample size of the study was small and the two techniques were applied to different lesions.

<Summary>

– The decision to select the parallel or perpendicular technique for targeting the nodule is considered mainly the operator's preference.

Processing of FNA Samples for Cytologic Diagnosis

Cytologic details of samples will vary depending on the experience of the technical staff or laboratory facilities for handing specimens obtained by US-FNA, thus proper methods should be applied during smearing, fixation, and staining of samples to improve diagnostic yield (1). For conventional smear preparations, the syringe-needle unit is disassembled first. The empty syringe is then filled with air, reconnected to the needle and the needle content is extruded onto glass slides. After that, FNA samples fixed in 95% ethyl alcohol for Papanicolaou staining can be used for immediate cytologic assessment (1, 45). Sometimes, excessive pressure between the spreader slide and non-spreader slide results in crush artifacts which may interfere with evaluation of nuclear morphology (1, 4).

Therefore, liquid-based cytology (LBC), originally developed for gynecologic cervical smears, was recently introduced for the FNA of thyroid nodules due to its specific advantages including clear background, a monolayer cell preparation, and more convenient handling of specimens (1, 45-47). This method is based on a two-step procedure: 1) fixation of the aspirated material in an alcohol-based solution and 2) automated processing of the material to obtain the representative cells in a thin layer on a single slide. Previous studies demonstrated that LBC showed either a lower nondiagnostic rate or a similar diagnostic rate for atypical/neoplastic lesions compared with the previous conventional smear method, despite the rising cost (1, 7, 46, 47). However, several changes that occur during the cellular processing step of LBC, such as loss of cell artitecture, cytomorphologic changes of colloid, and decrease of inflammatory cells, were pointed out as the drawbacks of LBC. Therefore, a dedicated training program would be necessary for cytopathologists to maintain the diagnsotic accuracy of US-FNA (1, 47).

To summarize the advantages of two different cytologic preparation methods, cellular specimen processing by conventional smear techniques enables rapid, real-time assessment of sample adequacy and allows for a more accurate evaluation of cell architecture and colloids than LBC, whereas LBC enables rapid processing of samples with clearer backgrounds than conventional smears and the possibility of saving material for additional marker studies.

<Summary>

– LBC might be a complimentary cytologic processing step for thyroid nodules alongside the conventional smear.

Immediate Assessment of Cytologic Adequacy

The role of immediate cytologic assessment is controversial (9). Many previous reports have stated that immediate assessment of cytologic adequacy at the time of FNA significantly decreased the numbers of nondiagnostic results and helped to avoid repeated FNAs (10, 48-51). However, others did not find a statistically significant difference in cytologic adequacy between FNAs of thyroid nodules with and without immediate cytological analysis, and stated that immediate cytological analysis considerably extended the cost and duration of the procedure (52). It may not be necessary for the success of the procedure to perform an immediate assessment, especially if a highly-experienced operator with a relatively low nondiagnostic rate performs the US-FNA for the thyroid nodule (51). Rather, immediate cytologic assessment can be reserved for the less-experienced operator and for repeat FNA of thyroid nodules with previous nondiagnostic results if available (50, 51, 53).

<Summary>

– Immediate assessment of cytologic adequacy might be helpful depending on the experience of the operator who performs US-FNA for the thyroid nodule.

Post-Procedural Management

Generally, the risk of FNA-related bleeding diminishes with a few minutes of manual compression immediately after needle withdrawal (31). Upon completion of the FNA procedure, the operator should examine the patient's neck to identify any bleeding-related manifestations, such as progressive swelling or ecchymosis. In addition, it would be empirically recommended for the patient to manually compress the skin puncture site for an additional 20–30 minute observation period after US-FNA and his or her neck should be ultrasonographically re-examined if FNA-related complications are suspected. This is especially important in patients with bleeding tendencies and these patients should be observed for 30–60 minutes to detect any bleeding-related symptoms (31). Local pain or bruising can be minimized by an ice pack. The patient should be discharged with instructions to seek medical care if sudden swelling or unrelenting pain occurs (31).

<Summary>

– Direct manual compression at the biopsy site is essential to reduce the risk of procedure-related complication.

Management of US-FNA Related Complications

In regard to complications related with US-FNA, there is limited epidemiological data on the incidence and the relation to techniques including needle size, number of passes or the technique used. However, the possibility and severity of complications, including hemorrhage, may be increased by a medical history of hemorrhagic risk factors, thicker needles, vigorous handling of the needle, or lack of operator experience (12, 25). Local pain and ecchymosis are the most frequent complications related to US-FNA, however, serious events are very rare (4, 5, 8, 25, 34). Other complications related to US-FNA are as follows: major hematoma, subendothelial hematoma, vasovagal reaction, trachea or esophageal injury, and tumor seeding (4, 5, 25). Most of the complications related to US-FNA can be sufficiently managed if the physician is aware and the patient is informed (8, 9).

Local Pain and Ecchymosis

Local pain and slight ecchymosis related to minor hematomas are relatively tolerable; however, if they persist, mild painkillers such as Tylenol or temporary application of an ice pack on the painful area can control the pain very well (9). Aspirin or aspirin substitutes (Motrin, Naprosyn) should not be taken within 48 hours after the procedure, although there is no direct evidence against them.

Hemorrhage

Intrathyroidal- or perithyroidal-hemorrhage after US-FNA might be caused by venous extravasation into or around the nodules. Clinical manifestations of hemorrhage include increased pain, swelling and ecchymosis of the neck, dyspnea, dysphonia and dysphagia (9, 25). If hemorrhage is suspected, the patient's neck should be sonographically examined to ensure stabilization prior to discharging the patient. Small to moderate-sized hematomas can be successfully managed in out-patient settings with manual compression as well as an ice-pack and they usually resolve spontaneously within days. Only a few cases of uncontrolled hemorrhage, requiring hospital admission and more active intervention, have been reported in the literature (25, 28-30). A massive hematoma may result in tracheal deviation and/or compression and can be fatal if acute upper airway obstruction develops rapidly. Proper preventive efforts should be considered, especially for patients with bleeding tendency, before and during the procedure, and prompt intervention including endotracheal intubation and tracheostomy or decompression surgery (hematoma evacuation, ligation and/or thyroidectomy) should be considered upon detection.

Rarely, subendothelial carotid hematoma manifests as acute, persistent pain immediately after US-FNA (54). To prevent bleeding around the thyroid glands or a potential complication such as pseudoaneurysm, firm pressure should be applied after confirming the presence of a hematoma. Reduced activity and upper positioning of the head can be useful to decrease the spread of hematoma along the vessel wall. Usually, the hematoma absorbs spontaneously within a week.

Vasovagal Reaction

Some patients experience vasovagal reactions, such as light-headedness, nausea, sweating, clammy hands or seizure-like activity, due to pain or anxiety about the procedure, prior to, during, or after the procedure (9). Especially, seizure-like activities such as uncontrollable jerking movements of the arms or legs can make the patients feel very scared. The symptoms usually last for 2–3 minutes. It is advisable to calm the patient by placing them in a supine position with legs slightly elevated and cold compression applied to the forehead (8, 9). Vital signs should be immediately monitored.

Tumor Seeding

The incidence of needle track seeding following FNA of thyroid carcinomas is exceedingly rare and only a few cases have been reported in the literature (25). Although the evidence is limited, several factors have been presumed to cause needle tract seeding, including larger needle size, excessive or vigorous needle manipulation, withdrawing the needle without releasing suction, and inherent characteristics of the lesion (e.g., tumor size, tumor aggressiveness). In all described cases, surgical treatment successfully removed the tumor seeding, and there was no evidence of recurrence during the follow-up period.

Others

Inadvertent puncture of the trachea during US-FNA may manifest as coughing, loss of vacuum in the syringe and/or a small amount of hemoptysis and most episodes are self-limited (25). Other rare complications are pseudoaneurysm, recurrent laryngeal nerve palsy, infection or post-FNA thyrotoxicosis (9, 25).

Strategies for Minimizing Nondiagnostic Results

Although US guidance ensures safe and exact targeting, the rates of nondiagnostic FNA results were highly variable and ranged between 0.4–40.7% (12-24, 39, 55). "Nondiagnostic" means that the slide prepared by US-FNA contains fewer than six follicular groups, each of which contains 10 or more well-preserved epithelial cells, inevitably limiting definitive cytologic interpretation (1, 5, 6). "Insufficient", "unsatisfactory", or "inadequate" can also be used in the same sense (5).

Considering the fact that the results of US-FNA have primarily supported the decision on whether to manage the thyroid nodule medically or surgically, its overall diagnostic yield, which reflects the operator's level of proficiency in this technique, should be continuously monitored (1, 56). Measuring technical proficiency in US-FNA ideally would include monitoring the frequency of nondiagnostic material leading to missed or delayed diagnoses of cancers. However, this approach is quite difficult because it requires large numbers of cases and access to long term reliable follow-up in all cases, not just those referred to surgery soon after FNA. For these reasons, the nondiagnostic rate of each operator, documenting the number of nondiagnostic results divided by the number of total FNA procedures, may be used as a limited indicator for the level of proficiency (56). Based on our expert consensus, it is recommended that the US-FNA results of individual operators be periodically assessed to confirm whether nondiagnostic rates are less than 10–15% or not.

From the thyroid nodules classified as nondiagnostic after initial US-FNAs, up to 34% were reported to be persistently nondiagnostic at subsequent US-FNAs. Moreover, 2.0–14.0% were eventually proved to be malignant upon obtaining surgical specimen (14, 15, 23, 24, 39). So, nondiagnostic FNA results should not be regarded as simply benign. To avoid delays in the detection of malignant thyroid nodules and unnecessary surgeries, the American Thyroid Association, the American Association of Clinical Endocrinologists, the Associazione Medici Endocrinologi, and the European Thyroid Association recommend a repeat FNA under US-guidance if an initial FNA yields nondiagnostic results (1, 4, 6, 57). In general, repeat US-FNA is recommended after a minimum interval of three months to prevent false-positive interpretations caused by reactive or reparative changes (1, 4, 6, 57). In contrast, two recent studies demonstrated that repeat FNAs within a shorter interval did not significantly influence the diagnostic yield of thyroid nodules with previously nondiagnostic results (58, 59). Therefore, a shorter waiting period may be possible in some patients if malignancy is highly suggested by clinical or US features (57). Alternatively, a core needle biopsy is recommended as a complimentary tool to patients for whom previous FNA results are nondiagnostic to improve the diagnostic yield of US-FNA (60, 61).

Apart from cytologic preparation and interpretation of FNA specimen, the diagnostic yield of US-FNA highly depends on both the US appearance of the thyroid nodule and the operator's experience (Table 1) (12-22). For example, certain US features such as cystic dominancy, macrocalcification, size less than 5–10 mm, or hypoechogenicity, have been reported to increase the likelihood of nondiagnostic sampling despite highly variable nondiagnostic rates between studies (13-16, 18-21, 23, 39, 62-64). Particularly, cystic dominancy and intranodular macrocalcification were reported to be independent findings that increase the possibility of nondiagnostic results, even when experienced operators performed US-FNA (13).

Although overall diagnostic rate was significantly improved in a previous study from 67% to 89% by standardization of technique: US guidance, 25-gauge needle, four passes and preparation of samples (four total smears: two air-dried, two fixed, with LBC and/or cell block) (55), the gauge of the needle, the number of passes and the need for negative suction should be determined in consideration of the US features of the individual thyroid nodule. For example, a 22-gauge or larger needle and/or greater negative suction pressure would be recommended for a hard thyroid nodule from which sufficient amount of cells could not be obtained easily, while a smaller needle or capillary sampling would be appropriate for targeting a hypervascular thyroid nodule (1, 9, 12, 31, 40). Especially for a nodule with peripheral calcification, it would be helpful to target the specific portion that favors the possibility of malignancy, such as the area with focal discontinuity or soft tissue rim, rather than an egg-shell like completely calcified rim (32, 39, 64). Furthermore, previous studies indicated that approximately 2.2–2.5% of thyroid cancers showed marked cystic changes (> 50%) and at least one suspicious feature, such as microcalcification, eccentric solid nodule, hypoechogenicity or irregular thick wall, coexisted besides the marked cystic changes (62, 63). Therefore, FNA sampling should be specifically targeted to the internal solid portion that suggests malignancy after drainage of cystic content.

Similar to other operator-dependent procedures, significant differences existed in nondiagnostic rates when US-FNAs were performed by highly experienced versus less experienced groups (13, 14, 19). For example, nondiagnostic rates from one comparative study on operator experience were 15.6% for radiologists with more than a year of experience and 25.8% for those with less (13). In a recent study, nondiagnostic US-FNA rate for radiology residents progressively declined with training levels. Therefore, the researchers emphasized the role of early and continued participation in the procedures throughout residency (65). To improve the skill of inexperienced operators, training should consist of an initial observation period to learn the indications and technical aspects of US-FNA as well as communication skills (1, 14, 56). Only after this observation period should the trainee perform the procedure under the supervision of an expert radiologist (14, 56).

Table 1. Comparison of Factors Affecting Nondiagnostic Rate of US-FNA

Author	Year	No. of Total FNA Done	ND Rate (%)	Significant	Non-Significant
Alexander et al. (15)	2002	1229	13	Cystic change: only significant and independent predictor of nondiagnostic cytology	Size
Ghofrani et al. (51)	2006	981	6.5	Immediate assessment of cytologic adequacy	
Degirmenci et al. (12)	2007	232	33.6	Needle size, capillary sampling	Increasing vascularity, hypoechogenicity
Sidiropoulos et al. (55)	2009	264	7.2	Standardization of US-FNA: 25-G, 4 passes and preparation of samples (four total smears: two air-dried, two fixed), LBC and personnel involved	
Baier et al. (22)	2009	944	11.8	Old age > 75 yr, size ≥ 10 mm	
De Fiori et al. (14)	2010	700	13.7	Experience of operator	
Gursoy et al. (19)	2010	1320	9.4	Experience of operator	
Moon et al. (18)	2011	1493	10.5	Cystic dominancy > 50%, hypoechogenicity, size < 5 mm	Gender, age, margin, calcification
Choi et al. (13)	2011	4077	16.1	Cyst dominancy, macrocalcification, experience of operator	
Moon et al. (16)	2012	1440	17.8	Size < 6 mm	
Wu et al. (20)	2014	710	11.4	Hypoechogenicity with avascularity, hypoechogenicity with hard pattern	
Grani et al. (21)	2013	1195	36.4	Size < 10 mm, hypoechoic, blurred margin	Micro-/macrocalfication, increased vascularity

Note.— ND = non-diagnostic, US-FNA = ultrasound-guided fine needle aspiration

<Summary>

– For effective management of thyroid nodules, an operator would clearly understand the technical details of US-FNA and be responsible for increasing the diagnostic yield of FNA by continuous monitoring of his/her nondiagnostic rate.

– Training for US-FNA would include the knowledge of US appearances of thyroid nodules, prevention and management of procedure-related complications, patient-care skills, as well as technical work under the close supervision of an expert radiologist.

CONCLUSION

Ultrasound-guided fine needle aspiration has been widely used as the main diagnostic method for patients with thyroid nodules, which have been increasingly detected following advancement of US technique. However, the overall diagnostic yield of this method has been highly variable. To optimize patient care, safety, and the diagnostic yield of US-FNA, radiologists should understand the technical details, cytologic preparation, and procedure-related complications associated with US-FNA.

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