3 Nondiagnostic/Unsatisfactory Thyroid Fine Needle Aspiration on Liquid-Based Preparations

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Introduction to Adequacy Criteria for Thyroid FNA Specimen

- Thyroid fine needle aspiration (FNA) is well established as a first-line diagnostic procedure in patients with thyroid nodules, but despite improved FNA techniques and increase use of ultrasound (US) guidance, about 20% of initial FNA specimens may be nondiagnostic or unsatisfactory (ND/Unsat).
- Nondiagnostic FNA of thyroid nodules presents a clinical dilemma, as the nature of the nodule is not clear and the nodule must be re-aspirated for a diagnosis.
- An adequate FNA specimen, representative of the lesion, is necessary to make an accurate cytopathologic interpretation for proper patient management.
- Adequacy encompasses adequate specimen cellularity and satisfactory specimen quality (thickness, fixation, and staining).

TBSRTC Criteria for Adequate Thyroid FNA Specimen and Application to LBP

- In The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) [2], a thyroid FNA is defined as "Adequate" when it contains six well-preserved, well-stained follicular cell groups with 10 cells each or 60 follicular cells (Fig. 3.1a, b).

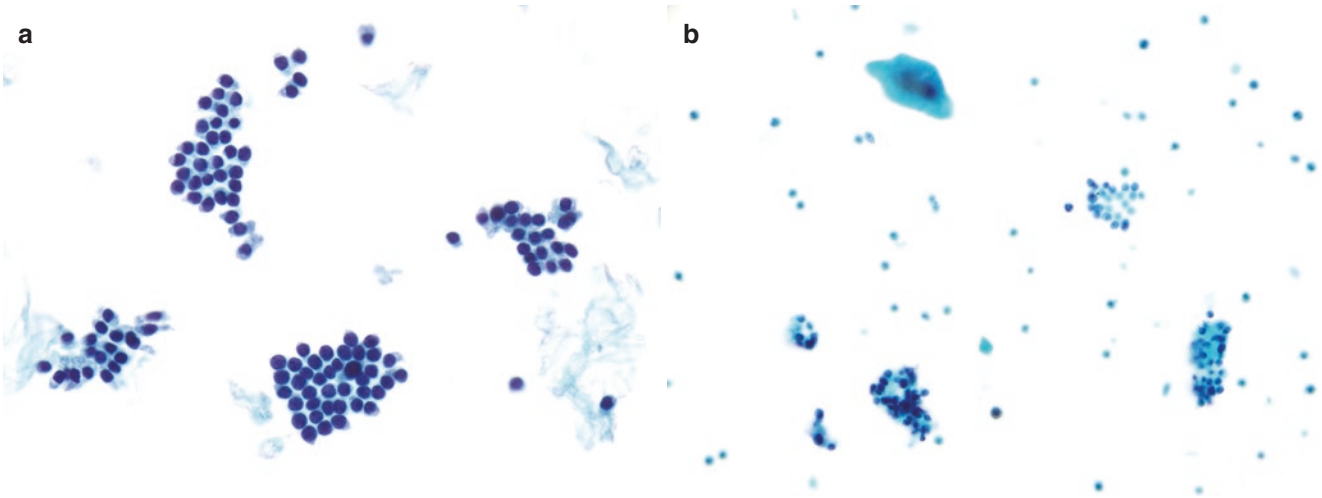

Fig. 3.1 Adequate thyroid FNA. (**a**, **b**) The case showed the required number of six groups of follicular cells with at least 10 cells each. The follicular cell groups are well preserved, well stained, and not covered by any background factors obscuring their features. Benign features are indicated by small, flat sheets of polarized, uniform follicular cells with regular, small, round nuclei and intact cytoplasm. A few small groups and single follicular cells are also present. Note the thin colloid appearance of "wrinkled tissue paper" (**a**, Papanicolaou [Pap] stain ThinPrep® [TP] and **b**, Pap stain, SurePath [SP])

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- A benign diagnosis with 60 benign follicular cells has 97% sensitivity and 42% specificity.
- Adequacy criteria on liquid-based preparations (LBP) are the same as those for conventional smears (CS).
- Use of these well-defined criteria for adequacy is helpful, as they improve the diagnostic efficiency of thyroid FNA.
- The overall risk of malignancy (ROM) in this category is 5–10%.
- On surgical resection, the malignancy rate for a nodule initially reported as ND/Unsat is 9–32%.

TBSRTC Criteria for ND/Unsat Thyroid FNA Specimen and Application to LBP

- In TBSRTC, ND/Unsat cytologic diagnoses are synonymous.
- The following are examples of thyroid FNA that are considered "ND/Unsat"
  - Cases with fewer than six well-preserved, well-stained follicular cell groups with 10 cells each, or <60 follicular cells. The same criteria apply to LBP (Fig. 3.2).
  - Cases with smear-related artifacts that compromise cell detail and interfere with accurate interpretation (Fig. 3.3a). Artifacts include air-drying, which is seen in alcohol-fixed slides stained with Pap stain and results from a delay in slide fixation. Other artifacts include obscuring of cells by blood (Fig. 3.3b)., ultrasound gel, or thick cellular areas. Because of the processing techniques in LBP, the background elements are reduced, and even if they are present, they do not obscure cells (Figs. 3.3c and 3.4a, b).
  - Cases with cyst fluid, with or without histiocytes, and fewer than six groups of 10 benign follicular cells. Cystic lesions are most commonly responsible for ND/Unsat cases (Fig. 3.5a–c).

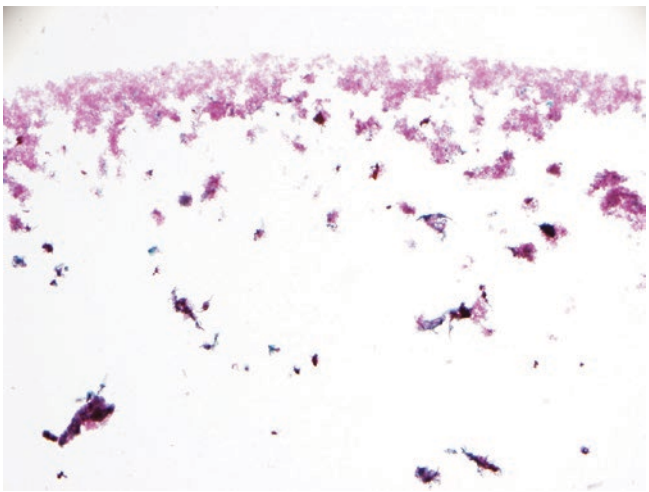

Fig. 3.2 Nondiagnostic/Unsatisfactory (ND/Unsat) in LBP. ND/Unsat TP case showing abundant blood only. TP is more likely to be ND/Unsat due to excess blood (Pap stain, TP)

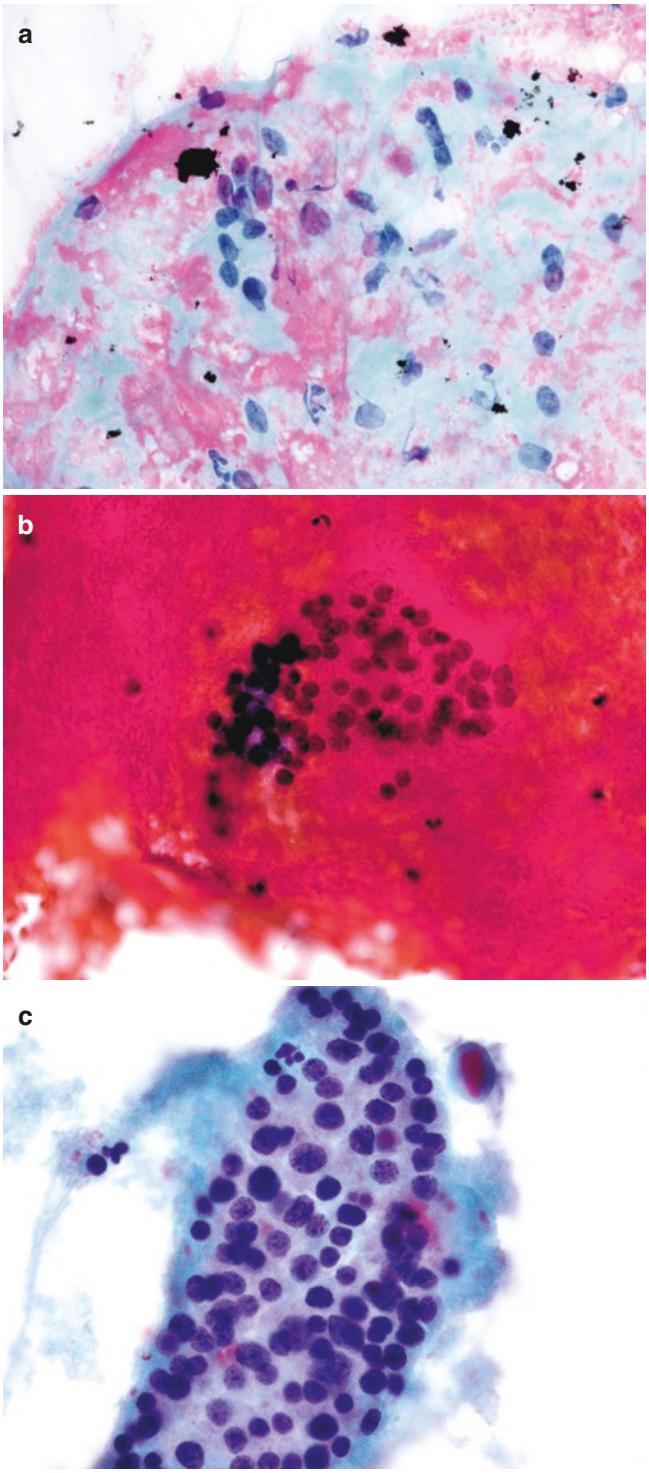

Fig. 3.3 ND/Unsat due to Smear-related Artifacts. (**a**) In a CS case, air-drying distorts cells and prevents a definitive diagnosis. (**b**) Excess blood in a CS case obscures cell detail; even though the cells look benign, it may be difficult to render a definitive diagnosis. (**c**) TP, a liquid-based preparation (LBP), shows abundant blood with no obscuring (**a–c**, Pap stain)

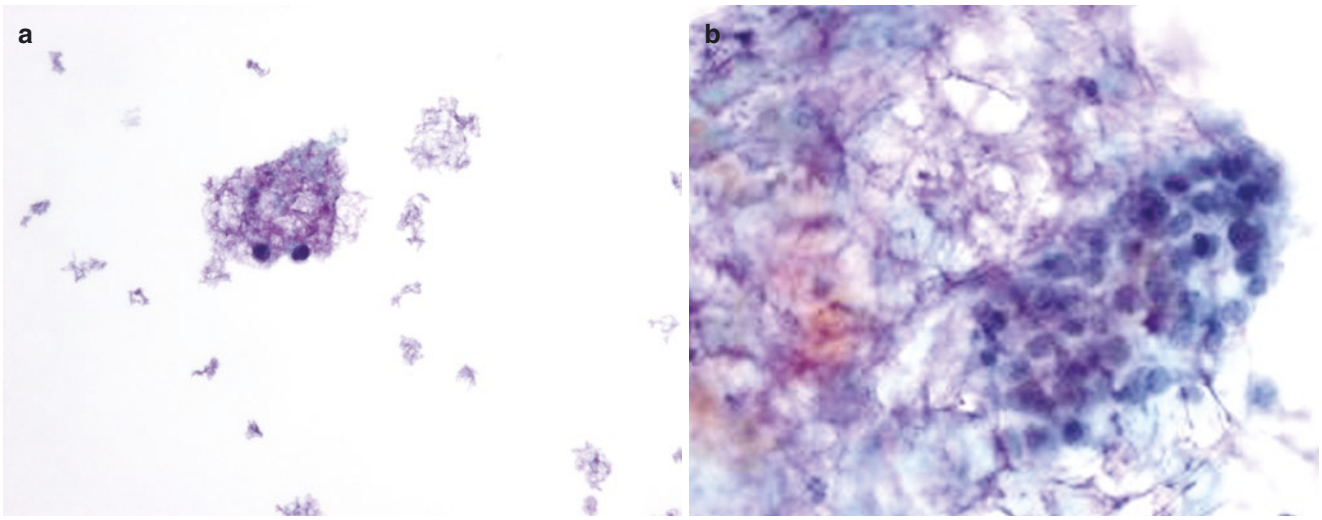

Fig. 3.4 ND/Unsat with Ultrasound Gel Only. (**a**) In LBP, the ultrasound (US) gel stains purple with a lacy or weblike texture. (**b**) The case showed follicular cells surrounded by US gel, but the cytology of benign follicular cells in a macrofollicle is not obscured (**a**, **b**, Pap stain, TP)

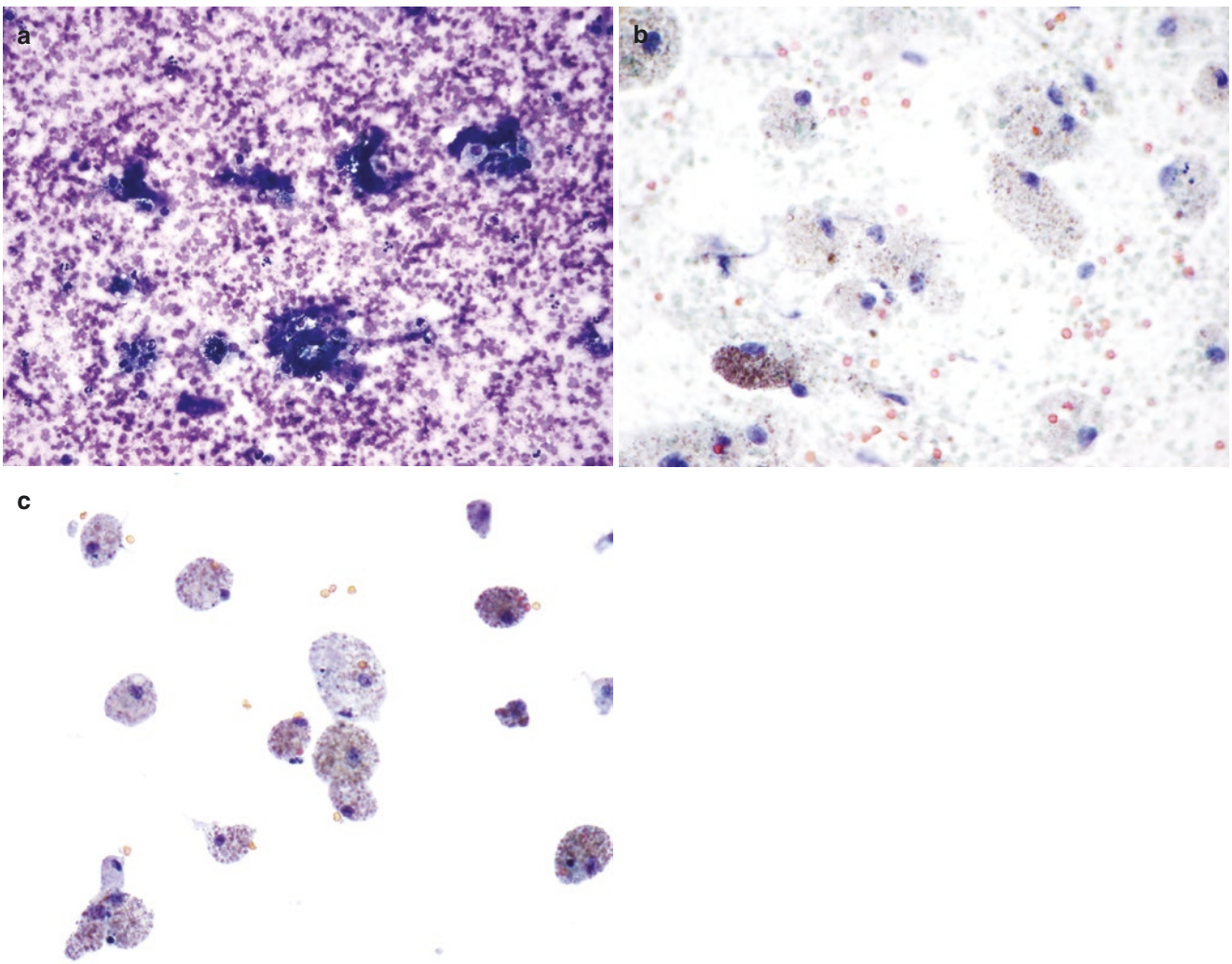

Fig. 3.5 ND/Unsat, Cyst Fluid Only. (a) On Diff-Quik (DQ)-stained CS, a cystic nodule shows non-cohesive macrophages with ill-defined cell walls and cytoplasmic hemosiderin pigment, which appears dark blue. (**b**) Pap-stained CS from the same case shows golden brown cytoplasmic hemosiderin pigment and red blood cells (RBCs) and cystic debris in the background. (**c**) When processed with TP, cystic fluid from the same case showed hemosiderin-laden macrophages with distinct cytoplasmic contours in a clean background. LBP retain all cytoplasmic elements. Nuclear morphology is crisp, with round, oval, and reniform shape, pale chromatin, and small nucleolus. Note RBCs in the background (Pap stain)

TBSRTC Exceptions to Adequacy Criteria, and Application to LBP

- There are exceptions to the ND/Unsat criteria:
  - *Colloid nodule:* This is composed of variably sized dilated follicles filled with colloid, which produce a specimen composed entirely of colloid (Fig. 3.6). Such a nodule contains abundant colloid, and the minimum number of follicular cells is not required, but this standard can only be reliably applied to CS. In LBP, the amount of thin colloid may be reduced and cannot be quantified accurately, so this diagnosis is not recommended for LBP. Moreover, the quality of colloid also changes; it may be mistaken for serum. Thyroglobulin immunostain can be performed, if needed, as colloid stains with thyroglobulin.
  - *Solid nodule with thyroiditis:* Thyroiditis is a diverse group of disorders with different etiologies that are characterized by thyroid inflammation. It is categorized as acute, subacute, or chronic forms. The latter, chronic lymphocytic thyroiditis (CLT) or Hashimoto's thyroiditis (Fig. 3.7a–c) is the most common form of thyroiditis. FNA cytology shows increased background lymphocytes, lymphocytic infiltration of Hürthle cells, and/or follicular cell clusters and lymphohistiocytic aggregates. In ThinPrep® (TP), the diagnosis of CLL or Hashimoto's thyroiditis sometimes may be challenging because of low cellularity and fewer lymphocytes or clumped lymphocytes. The latter may be mistaken for follicular cells. (*See* Chap. 4 for details on HT.)
  - *Solid nodule with any cytologic atypia:* This feature is applied regardless of the number of follicular cells; it is seen in LBP (Fig. 3.8a–c).

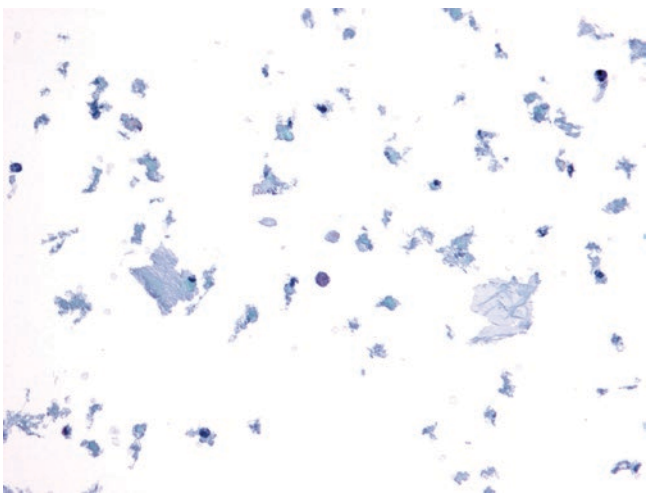

Fig. 3.6 ND/Unsat, Colloid Only in LBP. In CS a diagnosis of colloid nodule can be rendered if abundant colloid is present and the minimum number of follicular cells is not required. This standard can only be reliably applied to CS. In LBP, the amount of thin colloid may be reduced and cannot be quantified accurately. In this case, the TP shows only thin colloid only and is best considered ND/Unsat (Pap stain)

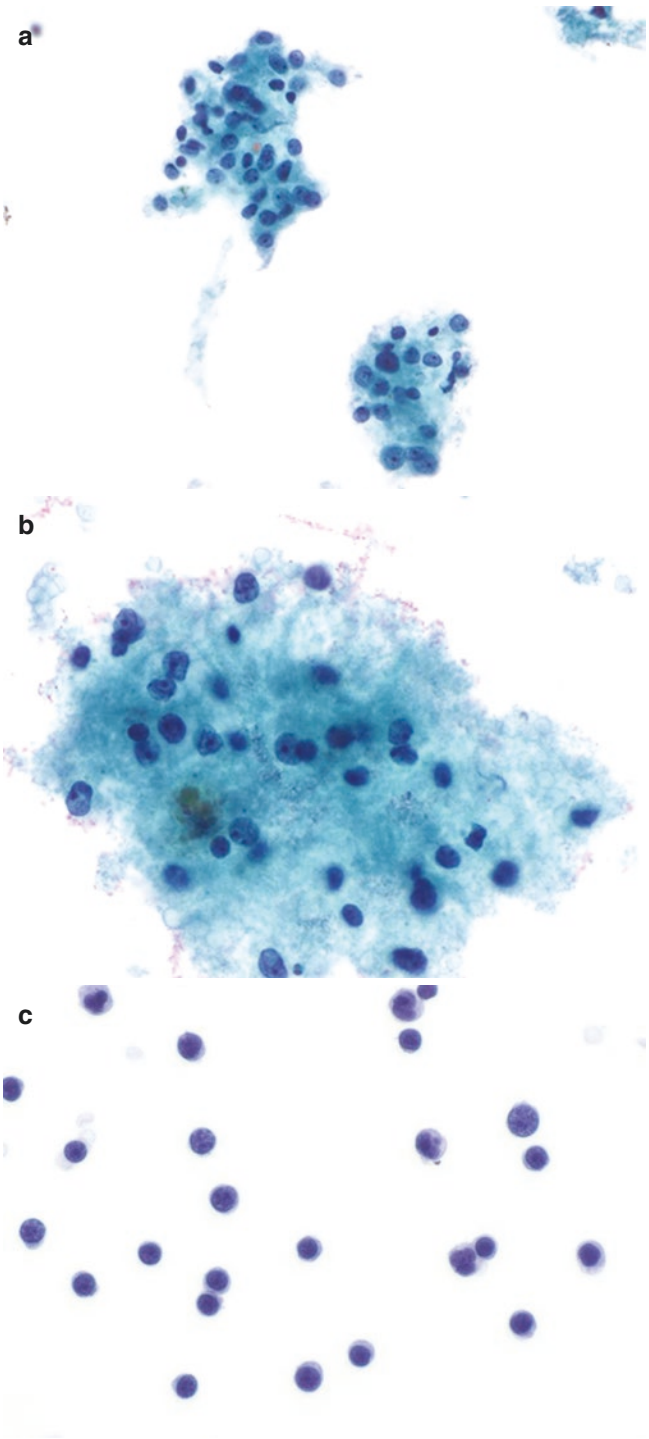

Fig. 3.7 Adequate, Hashimoto's Thyroiditis (HT). (**a**–**c**), Specimen shows lymphohistiocytic aggregates and dispersed polymorphous lymphocytes. No follicular cells were identified. (**a**–**c**, Pap stain TP). In TBSRTC, a minimum number of follicular cells is not required in these cases, but ancillary studies such as flow cytometry can be helpful for lymphocyte-only aspirates if the lymphoid population appears monoclonal

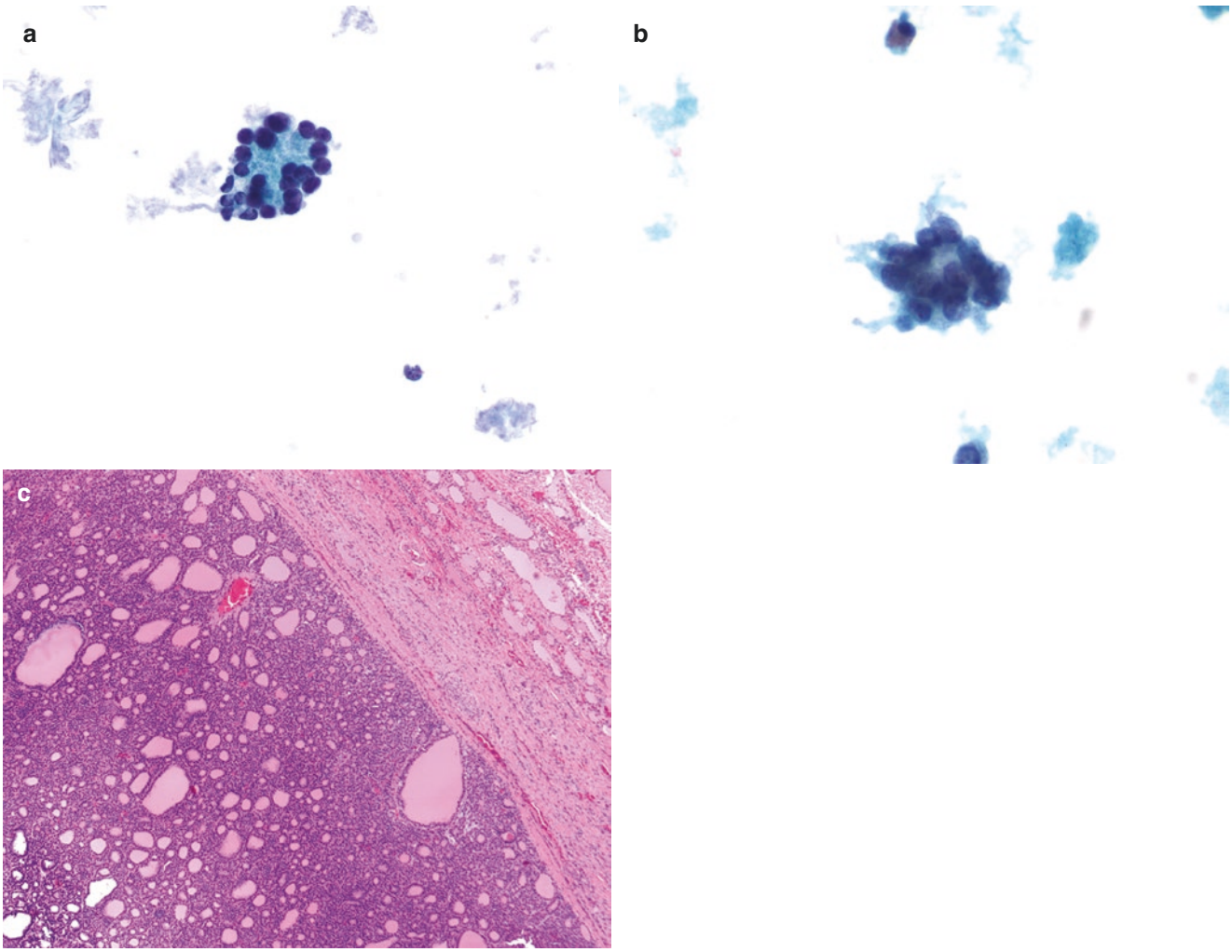

Fig. 3.8 Adequate, AUS/FLUS. (**a**, **b**) Specimen shows few atypical follicular cells (<60), with both nuclear and architectural atypia. The enlarged nuclei (compare with scattered RBCs in both images) are round and hyperchromatic, with occasional small nucleoli, and present in a microfollicular structure. Nuclear features of papillary thyroid carcinoma (PTC) are not seen (**a**, TP; **b**, SP; Pap stain). The thyroid molecular test showed a *NRAS* mutation in both cases. (**c**) On subsequent lobectomy, a histologic section from the nodule seen in (**a**) proved to be a follicular adenoma (hematoxylin & eosin [H&E] stain)

TBSRTC Updates for ND/Unsat Specimens

- Repeat FNA for a ND/Unsat can be performed at an interval of less than 3 months, but the potential for reactive/reparative atypia remains. The American Thyroid Association (ATA) 2015 guidelines [17] also state that a waiting period is probably not necessary.
- Repeat FNA after an ND/Unsat aspirate is often successful and results in a diagnostic sample in 60–80% of cases. This should be the standard approach to ND/Unsat nodules, given the ROM [1, 29]. Ultrasound-guided FNA (USGFNA) is preferred for repeat FNA.
- Patients with repeatedly ND/Unsat nodules should be closely observed or undergo surgical excision, especially if nodule size increases and sonographic findings are suspicious.

Causes for ND/Unsat Thyroid FNA and Application to LBP

- The most common pitfalls for false negative diagnoses in thyroid FNA result from rendering an interpretation on an inadequate sample from a solid nodule, or underdiagnoses of papillary thyroid carcinoma (PTC) due to cystic degeneration. A ND/Unsat sample should not be regarded as negative [29].
- Inadequate sampling of a solid nodule could be due to small nodule size, location in the thyroid, fibrosis, calcification, and excessive blood in the sample. The problem of excessive blood does not apply to LBP.
- The majority of ND/Unsat FNA results are due to cystic lesions. In such cases, the sample may consist solely of histiocytes and/or hemosiderin-laden macrophages. These

cases should be evaluated cautiously, with clinical and imaging correlation. A descriptive ND/Unsat diagnosis can be rendered, and the clinician can be alerted to the possibility of an underlying unsampled lesion such as PTC with cystic degeneration. In a review of 927 consecutive aspirations, García-Pascual et al. [14] reported an 11.1% malignancy rate among partially cystic thyroid nodules with ND/Unsat FNA cytology.

ND/Unsat Specimens in LBP

- Details of ND/Unsat cytology have been published in the Second Edition of the Bethesda System for Reporting Thyroid Cytopathology; the emphasis here is on ND/Unsat cases on LBP.
- Adequacy criteria for thyroid FNA in the TBSRTC were developed on CS, but they are also being applied to FNA evaluated with LBP alone.
- It remains controversial whether LBP should be the sole preparation used for thyroid FNA (direct-to-vial) or if LBP should be used in conjunction with CS (split sample). Each method has its proponents and opponents, and advantages and disadvantages.
- The inadequacy rate for LBP alone without CS is generally less than 15%, but the rate in LBP is higher if the split-sample technique is used. In this technique, cellular material is first smeared on slides and the residual specimen is then rinsed in liquid-based collection medium for LBP.
- In a study by Rossi et al. [26], three parameters of efficacy (rate of inadequate, indeterminate, and malignant) were evaluated in a series of 10,360 thyroid FNAs. The use of TP alone was as effective as CS in decreasing both inadequate and indeterminate cases. Most problems occurred when a split-sample method was used, with a resultant high rate of inadequate and false negative diagnoses.
- The sole use of LBP reduces the unsatisfactory rate and false negative diagnosis because of specific advantages that include a clean background, proper fixation, and increased cellularity (which occurs because the liquid-based slide is representative of the entire procured sample, unlike the split-sample method). See the study by Rossi et al. [26] for details of the two specimen collection techniques.
- The adequacy criteria in thyroid FNA evaluated with LBP alone have not been widely assessed. Vivero et al. [33] showed that in thyroid FNA examined with TP only, lowering the adequacy threshold and eliminating the requirement of six groups of 10 cells each does not significantly affect test performance if cytological features associated with malignancy are absent. Nevertheless, TBSRTC has retained similar adequacy criteria for both CS and LBP.
- A meta-analysis by Chong et al. [10] of studies on both LBP and CS published between 2000 and 2013 showed that sample adequacy for the two mainstream LBP methods (TP and SurePath™ [SP]) was significantly superior to CS for most sampling methods. Average sample inadequacy in TP studies (24.0%) was significantly lower than in CS (33.4%; $P < 0.01$). Likewise, average sample inadequacy in SP studies (7.1%) was significantly lower than in CS (13.2%; $P < 0.02$). In the same study, the sensitivity and specificity of LBP were similar or slightly better than for CS.
- When an LBP specimen does not contain an adequate number of cells, a second slide can be prepared with the residual material to help meet the adequacy criteria. Tulecke and Wang [31] and Rossi et al. [27] found good results with this technique. In the study by Rossi et al., this procedure led to an 18.5% increase in the overall diagnostic rate, especially in cases classified as benign and follicular lesions. Rossi et al. [27] and Tulecke and Wang [31] concluded that the making of a second slide for an ND/Unsat case with inadequate cellularity may improve the diagnostic efficacy of the technique and may avoid either a repeat FNA or more aggressive treatment.
- However, Hasteh et al. [16] found only a 3% adequacy retrieval rate for a second slide, which was regarded as insufficient for processing of an additional slide.
- Additional liquid-based slides can also be used for immunocytochemistry or molecular tests.
- A cell block (CB) can also be attempted from the residual specimen if the sample appears cloudy, bloody, or blood-tinged. Traditional CB sections not only serve as an important diagnostic adjunct to LBP or cytologic smears but also are used for immunohistochemical (IHC) studies.
- There are many ways to prepare a CB and the methods continue to be revised. Our group compared the traditional CB with CBs processed on the Cellient™ automated cell block system (Hologic, Toronto, Canada) [34]. The Cellient™ system, the first fully automated CB system, improves cell recovery when compared with traditional methods. The vacuum-assisted filtration concentrates available cells within the block, resulting in consistently high quality and a diagnostic CB in less than 1 hour, which can be used for IHC.
- Horton et al. [19] studied the utility of Cellient™ CBs in the evaluation of thyroid FNAs submitted in Cytolyt, with an emphasis on low-cellularity specimens. TP slides were first prepared from thyroid FNA. After assessment using TBSRTC criteria, Cellient™CBs were requested on samples with residual FNA material and an initial cytologic impression of ND/Unsat or AUS/FLUS, and on apparently benign samples with marginally adequate cellularity. Overall, the CB findings resulted in a

change of the initial TP impression in 15% of cases, the vast majority of which were initially ND/Unsat. Moreover, 31% of the ND/Unsat TP samples became diagnostic with a CB. The CB findings contributed to a change in diagnosis in 8% of AUS/FLUS cases. The low-cellularity benign samples gained very little additional information from the CB.

- Currently, TP is being used more often than SP for nongynecological cytology, including FNA, so more representations of TP cases will be seen. The choice of LBP depends on individual laboratory preferences and needs, however.
- Cytomorphological appearance is comparable with TP and SP, with subtle differences, as listed in Chap. 1 and mentioned elsewhere. A learning curve is essential for adapting to the cytomorphologic features of the LBP technique, and it is hoped that this volume will educate cytologists in the differences between CS and LBP and the subtle differences between TP and SP.

The Role of Rapid On-Site Evaluation for Adequacy Assessment and Application to LBP

- Air-dried Diff-Quik (DQ)–stained smears are prepared for rapid on-site adequacy evaluation (ROSE).
- ROSE of thyroid FNA reduces the ND/Unsat rate. This assessment provides a preliminary diagnosis, ensures that the sample is adequate, limits the number of passes, allows for appropriate specimen triage for ancillary studies including molecular tests, and often facilitates clinical decision-making. It is cost-saving, as a repeat FNA is avoided [35].
- ROSE cannot be performed for LBP, as the collected sample is immediately rinsed in the collection medium, but ROSE can be performed if LBP are used in conjunction with DQ-stained smears. Cytologists or clinicians who perform ROSE can make one or two DQ-stained smears per pass and if the specimen is adequate, the remaining sample can be rinsed in the liquid-based collection medium.
- The gauge of the FNA needle and FNA technique also influence the ND/Unsat rate. For solid and mixed nodules, the non-aspiration FNA method using a 25G needle with multiple (≥3) passes results in a higher diagnostic rate for thyroid FNA than does a single pass with a 22G needle, with or without aspiration.
- The study by Zhu et al. [35] revealed that when the number of needle passes was fewer than three, the nondiagnostic rate could be 25% or more, but it was significantly reduced to 11% with four passes performed per thyroid lesion. The authors concluded that, with ROSE, four to six passes per thyroid nodule is the optimal number to maximize diagnostic certainty.

The Role of Ultrasound-Guided FNA

- Ultrasound-guided FNA (USGFNA) is preferred over palpation-guided FNA (PGFNA).
- Although the rate of ND/Unsat FNA is reported to be lower with USGFNA, 10% to 35% of cases continue to be nondiagnostic. This rate includes both CS and LBP.
- USGFNA is more advantageous in nonpalpable, predominantly cystic nodules or nodules with previous ND/Unsat FNA.
- The 2015 ATA guidelines for management of adult patients with thyroid nodules and differentiated thyroid cancer indicate that PGFNA remains an acceptable alternative for FNA of a palpable thyroid nodule that meets sonographic criteria for biopsy [17].

Suggested Reading

1. Alexander EK, Heering JP, Benson CB, Frates MC, Doubilet PM, Cibas ES, et al. Assessment of nondiagnostic ultrasound-guided fine needle aspirations of thyroid nodules. J Clin Endocrinol Metab. 2002;87:4924–7.
2. Ali SZ, Cibas ES. The Bethesda system for reporting thyroid cytopathology; definitions, criteria, and explanatory notes. 2nd ed. Cham: Springer International Publishing AG; 2018.
3. Bongiovanni M, Papadakis GE, Rouiller N, Marino L, Lamine F, Bisig B, et al. The Bethesda system for reporting thyroid cytopathology explained for practitioners: frequently asked questions. Thyroid. 2018;28:556–65. https://doi.org/10.1089/thy.2017.0685.
4. Brito JP, Castro MR, Dean DS, Fatourechi V, Stan M. Survey of current approaches to non-diagnostic fine-needle aspiration from solid thyroid nodules. Endocrine. 2015;49:745–51. https://doi.org/10.1007/s12020-015-0539-4.
5. Chandanwale SS, Nair R, Gambhir A, Kaur S, Pandey A, Shetty A, et al. Cytomorphological spectrum of thyroiditis: a review of 110 cases. J Thyroid Res. 2018;2018:5246516. https://doi.org/10.1155/2018/5246516.
6. Chang H, Lee E, Lee H, Choi J, Kim A, Kim BH. Comparison of diagnostic values of thyroid aspiration samples using liquid-based preparation and conventional smear: one-year experience in a single institution. APMIS. 2013;121:139–45. https://doi.org/10.1111/j.16000463.2012.02944.x.
7. Cibas ES, Ali SZ. The 2017 Bethesda system for reporting thyroid cytopathology. Thyroid. 2017;27:1341–6. https://doi.org/10.1089/thy.2017.0500.
8. Clark DP, Faquin WC. Thyroid cytopathology. 2nd ed. New York: Springer; 2010.
9. Chong Y, Baek KH, Kim JY, Kim TJ, Lee EJ, Kang CS. Comparison of EASYPREP and SurePath in thyroid fine-needle aspiration. Diagn Cytopathol. 2016;44:283–90. https://doi.org/10.1002/dc.23438.
10. Chong Y, Ji SJ, Kang CS, Lee EJ. Can liquid-based preparation substitute for conventional smear in thyroid fine-needle aspiration? A systematic review based on meta-analysis. Endocr Connect. 2017;6:817–29. https://doi.org/10.1530/EC-17-0165.
11. Choong KC, Khiyami A, Tamarkin SW, McHenry CR. Fine-needle aspiration biopsy of thyroid nodules: is routine ultrasound-guidance necessary? Surgery. 2018;164:789–94. https://doi.org/10.1016/j.surg.2018.04.047.

12. Duncan LD, Forrest L, Law WM Jr, Hubbard E, Stewart LE. Evaluation of thyroid fine-needle aspirations: can ThinPrep be used exclusively to appropriately triage patients having a thyroid nodule? Diagn Cytopathol. 2011;39:341–8. https://doi.org/10.1002/dc.21392.
13. Ferreira MA, Gerhard R, Schmitt F. Analysis of nondiagnostic results in a large series of thyroid fine-needle aspiration cytology performed over 9 years in a single center. Acta Cytol. 2014;58:229–34. https://doi.org/10.1159/000360066.
14. García-Pascual L, Barahona MJ, Balsells M, del Pozo C, Anglada-Barceló J, Casalots-Casado J, et al. Complex thyroid nodules with nondiagnostic fine needle aspiration cytology: histopathologic outcomes and comparison of the cytologic variants (cystic vs. acellular). Endocrine. 2011;39:33–40. https://doi.org/10.1007/s12020-010-9409-2.
15. Geers C, Bourgain C. Liquid-based FNAC of the thyroid: a 4-year survey with SurePath. Cancer Cytopathol. 2011;119:58–67. https://doi.org/10.1002/cncy.20125.
16. Hasteh F, Pang Y, Pu R, Michael CW. Do we need more than one ThinPrep to obtain adequate cellularity in fine needle aspiration? Diagn Cytopathol. 2007;35:740–3.
17. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, et al. 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: the American Thyroid Association Guidelines Task Force on Thyroid Nodules and Differentiated Thyroid Cancer. Thyroid. 2016;26:1–133. https://doi.org/10.1089/thy.2015.0020.
18. Hoda RS, VandenBussche C, Hoda SA. Diagnostic liquid-based cytology. New York: Springer; 2017.
19. Horton M, Been L, Starling C, Traweek ST. The utility of Cellient cell blocks in low-cellularity thyroid fine needle aspiration biopsies. Diagn Cytopathol. 2016;44:737–41. https://doi.org/10.1002/dc.23522.
20. Jung CK, Lee A, Jung ES, Choi YJ, Jung SL, Lee KY. Split sample comparison of a liquid-based method and conventional smears in thyroid fine needle aspiration. Acta Cytol. 2008;52:313–9.
21. Lee HY, Baek JH, Yoo H, Kim JK, Lim MK, Chu YC, et al. Repeat fine-needle aspiration biopsy within a short interval does not increase the atypical cytologic results for thyroid nodules with previously nondiagnostic results. Acta Cytol. 2014;58:330–4. https://doi.org/10.1159/000363277.
22. Liu X, Zhu L, Wang Z, Cui D, Chen H, Wei L, et al. Comparison of two different standards of care in detecting malignant thyroid nodules using thyroid fine-needle aspiration. Mol Clin Oncol. 2015;3:682–6.
23. Ljung BM. Thyroid fine-needle aspiration: smears versus liquid-based preparations. Cancer. 2008;114:144–8. https://doi.org/10.1002/cncr.23541.
24. Pitman MB, Abele J, Ali SZ, Duick D, Elsheikh TM, Jeffrey RB, et al. Techniques for thyroid FNA: a synopsis of the National Cancer Institute Thyroid Fine-Needle Aspiration State of the Science Conference. Diagn Cytopathol. 2008;36:407–24. https://doi.org/10.1002/dc.20829.
25. Renshaw AA. Histologic follow-up of nondiagnostic thyroid fine needle aspirations: implications for adequacy criteria. Diagn Cytopathol. 2012;40(Suppl 1):E13–5. https://doi.org/10.1002/dc.21492.
26. Rossi ED, Raffaelli M, Zannoni GF, Pontecorvi A, Mulè A, Callà C, et al. Diagnostic efficacy of conventional as compared to liquid-based cytology in thyroid lesions: evaluation of 10,360 fine needle aspiration cytology cases. Acta Cytol. 2009;53:659–66.
27. Rossi ED, Morassi F, Santeusanio G, Zannoni GF, Fadda G. Thyroid fine needle aspiration cytology processed by ThinPrep: an additional slide decreased the number of inadequate results. Cytopathology. 2010;21:97–102. https://doi.org/10.1111/j.1365-2303.2009.00659.x.
28. Sahin D, Yilmazbayhan D, Firat P, Hacisalihoglu UP, Kirimlioglu SH, Celenk E, et al. Comparison of conventional cytology and SurePath in split thyroid fine needle aspiration materials. Cytopathology. 2017;28:291–8. https://doi.org/10.1111/cyt.12430.
29. Saieg MA, Barbosa B, Nishi J, Ferrari A, Costa F. The impact of repeat FNA in non-diagnostic and indeterminate thyroid nodules: a 5-year single-centre experience. Cytopathology. 2018;29:196–200. https://doi.org/10.1111/cyt.12508.
30. Sharma S, Agarwal S, Jain M, Singh GB, Andley M. Cytomorphological differences between liquid-based cytology and conventional smears in fine-needle aspirates of thyroid lesions. J Cytol. 2018;35:208–11. https://doi.org/10.4103/JOC.JOC_150_17.
31. Tulecke MA, Wang HH. ThinPrep for cytologic evaluation of follicular thyroid lesions: correlation with histologic findings. Diagn Cytopathol. 2004;30:7–13.
32. Upadhyaya P, Dhakal S, Adhikari P, Adhikari B, Khadka D, Niraula SR. Histopathological review of diagnostic categories of the Bethesda system for reporting thyroid cytopathology – an institutional experience of 5 years. J Cytol. 2019;36:48–52. https://doi.org/10.4103/JOC.JOC_64_18.
33. Vivero M, Renshaw AA, Krane JF. Adequacy criteria for thyroid FNA evaluated by ThinPrep slides only. Cancer Cytopathol. 2017;125:534–43. https://doi.org/10.1002/cncy.21858.
34. Wagner DG, Russell DK, Benson JM, Schneider AE, Hoda RS, Bonfiglio TA. Cellient™ automated cell block versus traditional cell block preparation: a comparison of morphologic features and immunohistochemical staining. Diagn Cytopathol. 2011;39:730–6. https://doi.org/10.1002/dc.21457.
35. Zhu W, Michael CW. How important is on-site adequacy assessment for thyroid FNA? An evaluation of 883 cases. Diagn Cytopathol. 2007;35:183–6.