Fine Needle Aspiration in Pediatric Patients: Approach and Technique

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2.1 Introduction

The statement "children are not just small adults" applies not only to clinical medicine, but also to pathology, as evidenced by formal recognition of pediatric pathology as a subspecialty. Successful use of fine needle aspiration (FNA) for the pathological evaluation of pediatric lesions poses special challenges and requires consideration of the patient's level of cognitive and emotional maturity, awareness of the diseases that occur in this population, and knowledge of the cytological features of those entities.

In children and adolescents, as in adults, FNA has the advantage of being a minimally invasive technique for obtaining diagnostic material from mass lesions. In experienced hands and in the appropriate clinical context, FNA has a sensitivity of approximately 97–98 % and a specificity of 93–97 % [1, 2]. In the pediatric population, use of FNA is particularly beneficial for evaluation of superficial lesions, many of which are reactive or infectious in origin. In this setting, FNA can confirm the benignity of the lesion and in some cases, provide a specific diagnosis through the use of ancillary studies, while avoiding the greater risks of core or open biopsy. For both benign and malignant lesions, on-site evaluation at the time of the procedure is important and can help to ensure adequacy, guide appropriate triage and, thereby, minimize the likelihood of a non-diagnostic specimen. When the FNA is performed by someone other than the pathologist, on-site evaluation also affords an opportunity to provide important feedback to the proceduralist and, for suboptimal specimens, may allow conversion to core biopsy, thereby averting the need for a second diagnostic procedure at a later time. While it is desirable to avoid the need for a repeat FNA or additional biopsy irrespective of the patient's age, subjecting a child or adolescent to a second procedure may be particularly burdensome to the patient and family in terms of emotional distress, the costs associated with time away from school, work, and caring for siblings and, in some cases, the need for sedation or anesthesia, none of which is trivial.

This chapter will highlight some of the key factors to consider when performing FNAs on pediatric patients.

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2.2 Pre-procedural Evaluation

The pathologist who performs an FNA serves as a consultant to the referring clinician and therefore, usually meets the patient and parent(s) or legal guardian for the first time at the time of the FNA. Ideally, the referring physician or physician extender communicates to the pathologist in writing his or her clinical suspicions and any pertinent history, physical findings, laboratory results, and/or imaging studies on which they are based, as well as any relevant pending studies. This can occur through a medical record to which the pathologist has access or through a letter or written request for consultation in cases in which the medical records are inaccessible to the pathologist. Oral communication initiated either by the clinician at the time of referral or by the pathologist when written communication from the referring clinician is lacking is an acceptable alternative, although less desirable due to the possibility of errors. The pathologist should review the patient's medical record when it is accessible, irrespective of any communication with the referring clinician. Ideally, information from the referring clinician and/or medical record provides the pathologist with important background data that may or may not be elicited at the time of FNA, but is not intended to replace communication between the pathologist and the patient and parent(s) or legal guardian. In addition to conveying important medical information, communication between the referring clinician and pathologist provides an opportunity to address key issues related to consent, such as who a minor child's legal guardian is and the need for an interpreter (see Sect. 2.3).

2.2.1 Clinical History

As noted above, the initial encounter between the pathologist performing an FNA and the child and parent(s) or legal guardian is usually at the time of the procedure. A successful interaction with the child and parent(s) or legal guardian requires appreciation of the child's level of apprehension, which may range from virtually absent to intense and is shaped by cognitive and emotional maturity, prior experiences with medical personnel and vaccinations, the degree to which the child has been prepared for the FNA, and his or her expectations around the procedure. Wearing street clothes rather than a white coat, and engaging the child in age appropriate conversation or other interactions prior to obtaining a clinical history and performing a physical examination can help to establish rapport with the child, as well as the parent(s) or legal guardian. At each stage of the encounter, it is important to include the child in the conversation at his or her cognitive level and talk with the child at his or her eye level, rather than simply talking about the child with the parent(s) or legal guardian. This is particularly important when the patient is a school age child or adolescent.

Clinical history is helpful for formulating a differential diagnosis and can provide important clues to the correct diagnosis. It is important to obtain a clinical history directly from the patient and/or parent(s) or legal guardian, rather than simply relying on information communicated by the referring clinician and/or contained in the medical record. Beyond helping to establish rapport with the patient and parent(s) or legal guardian, this allows the pathologist to validate the clinical history provided elsewhere and resolve any potentially important discrepancies or omissions. For example, when a child is referred with lymphadenopathy, there should be a discussion about exposure to cats or other animals, as well as any recent travel. The qualities of the lesion and how they have changed over time are also important. A mass lesion that has persisted and enlarged over a short period of time is more concerning for a malignancy than a lymph node that fluctuates in size over time. Results of laboratory tests, serologic studies, and microbiologic cultures can also be helpful. For example, in developed countries, many children and adolescents presenting with persistent lymphadenopathy will have had a tuberculin skin test, monospot test, Epstein–Barr virus (EBV) IgM and IgG titers, and *Bartonella* titers. Having the results of these tests can be very helpful when approaching the evaluation of these cases, although results may

not be available at the time of the procedure or may not have been conveyed to the parent(s) or legal guardian by the ordering clinician.

2.2.2 Physical Examination

After obtaining a history, a directed physical examination establishes the size of the lesion, its mobility (freely mobile or fixed), contour (ill- or well-defined), texture (soft, doughy/cystic, or firm), and any associated tenderness. This tactile contact with the patient not only allows the pathologist to guage the patient's level of anxiety about the procedure, but may also help the patient to feel more comfortable with the pathologist. When examining a school age child or adolescent, especially of the opposite gender, it is suggested that the pathologist be accompanied by a nurse or other health care assistant. Parents can be asked to leave or may stay, depending on the preference of the child.

2.3 Informed Consent

Prior to performing the FNA, informed consent is obtained. This includes an explanation of the procedure, its benefits, potential complications, and risks, including a non-diagnostic aspirate and the need for a second diagnostic procedure, and alternatives to FNA. The consent form is signed and dated by the physician and the patient's legal guardian, which in most cases is the parent. The consent form becomes part of the medical record. For children under the age of 18, who cannot legally consent to undergoing a procedure, it is imperative that the pathologist confirm prior to the appointment who will be accompanying the child and who the legal guardian is. If someone other than the legal guardian or parent will accompany the child, then it is important to obtain informed consent from the legal guardian or parent beforehand, usually by telephone with at least one witness. This occurs most often when a child who is in a foster home or other institution is accompanied by someone other than the legal guardian, but can also arise when a child is accompanied by a relative, such as a grandparent, who is not the legal guardian. A social worker or risk management personnel can usually help to determine and, if necessary, locate the legal guardian. However, this can take time and may delay or necessitate rescheduling of the procedure if not done beforehand. Of note, the consent laws of about 30 states and the District of Columbia give patients who are minors but are parents, married, or pregnant the legal capacity to consent for a procedure, while the remaining states have no explicit policy or law [3]. It is also recommended that, as part of the consent process, assent be obtained from school age children and adolescents to confirm that they are willing to undergo the FNA and to ease their anxiety. When obtaining consent and/or assent, it is important to be at eye level, to turn off all electronic devices that could be a distraction, to use basic language rather than medical terminology, and to make sure that the parent(s) or legal guardian and child understand what they have been told, are given the opportunity to ask questions and that their questions are answered to their satisfaction. When necessary, an interpreter employed by the facility in which the FNA is performed should be provided to ensure that the parent(s) or legal guardian and child understand the pathologist's explanations, have had their questions answered satisfactorily and are truly giving informed consent.

2.4 Equipment

The equipment required for the FNA procedure includes syringes, needles (22–27G), a syringe holder, such as the Cameco Syringe Pistol, glass slides, pencil or permanent marking pen, spray fixative or Coplin jar with 95 % alcohol, slide folders or plastic slide holders, staining solutions, sterile tubes, formalin-filled containers, alcohol wipes, gauze, band-aids, and personal protective equipment (Figs. 2.1 and 2.2). In the pediatric setting, it can be helpful to have colorful band-aids with patterns, superheroes, or other characters that children can identify with. These items can be stored in a labeled basket or cart for convenience

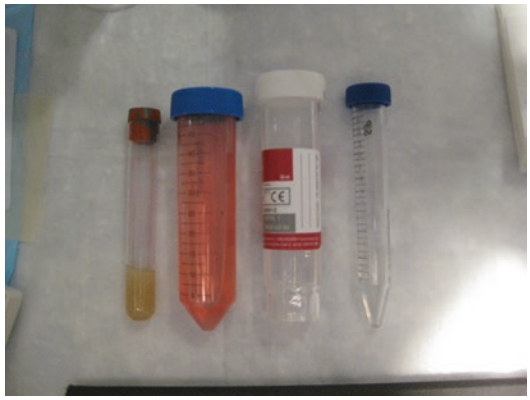

Fig. 2.1 Supplies for pediatric FNAs. Multiple supplies are needed during pediatric FNAs because of the variety of ancillary studies that may be required. It is usually helpful to have a variety of different containers (shown from *right* to *left*), including sterile tube for microbial cultures (*right*), liquid based cytology containers (e.g., Thin Prep™; *middle right*), container with fresh cold Roswell Park Memorial Institute (RPMI) media for flow cytometry (*middle left*), and tiger-top blood collection tubes (*left*) for tapping needles that have clotted material.

Fig. 2.3 An FNA basket utilized to carry materials to procedures. A crate or sturdy plastic tool box can be used to hold the materials needed for an FNA and allows the pathologist to be mobilized quickly to perform an FNA on a child in an outpatient clinic, operating room, or inpatient setting. An opaque container also maintains patient confidentiality when carrying materials back to the cytology laboratory after a procedure.

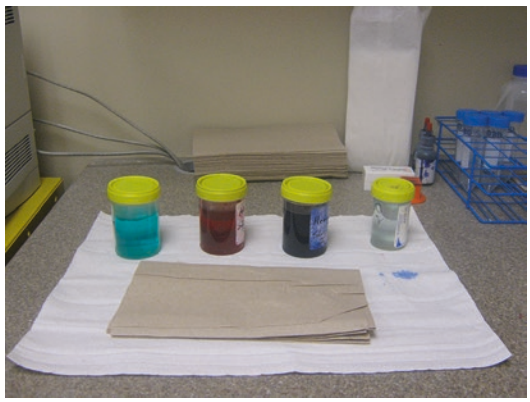

Fig. 2.2 Diff-Quik staining supplies. If on-site evaluation is performed, a rapid stain is necessary, such as a Romanowsky-type stain, like Diff-Quik. The staining takes less than 1 minute and is performed on air-dried smears. These slides can be examined without coverslipping.

(Figs. 2.3 and 2.4). If on-site evaluation and preliminary diagnosis are desired, then a microscope is also required, which can be placed on a mobile cart or in a permanent location in sites where FNAs are frequently performed (Fig. 2.4). A papoose or large blanket to wrap a child's extremities can also be very helpful to immobilize the non-sedated patient who is unable to cooperate (Fig. 2.5).

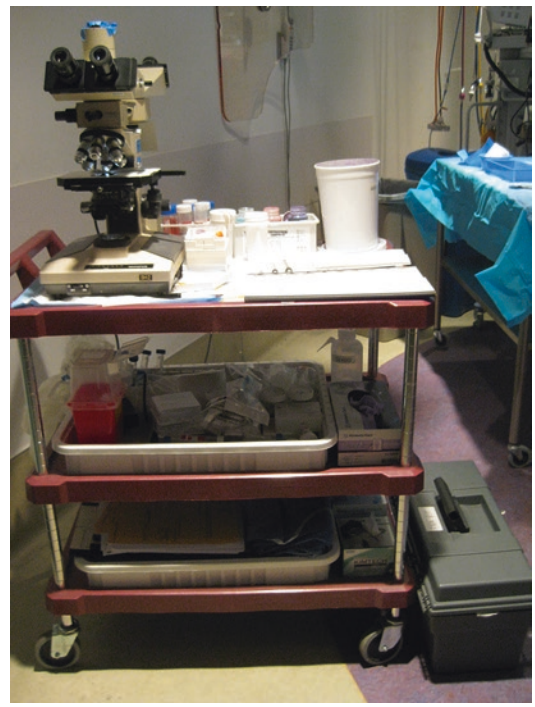

Fig. 2.4 FNA cart utilized for on-site evaluations. If on-site evaluation of an FNA is required, then an FNA cart stocked with a microscope and all necessary supplies is important.

Fig. 2.5 Papoose for immobilization of non-sedated pediatric patients. These immobilization devices allow the child to lie down on the flat board, while soft cloth arms are wrapped and secured around the child's arms and legs to prevent them from moving during the FNA procedure.

2.5 Fine Needle Aspiration Procedure

FNAs are performed by pathologists and other physicians in a variety of locations, including outpatient clinics, the operating room, at the bedside of hospitalized patients, and in the radiology suite. For non-palpable masses detected by imaging, CT or ultrasound (US) guidance should be used to perform the FNA. In addition to interventional radiologists, some pathologists are qualified to perform US-guided FNAs and may use portable ultrasound equipment in the clinic, operating room, or at the bedside. The techniques involved in US-guided FNA are beyond the scope of this discussion, which will be confined to FNA of palpable lesions. Prior to beginning the FNA, a "time out" is performed and documented to confirm the procedure, the patient's name and unique identifiers, and the location (anatomic site and laterality) of the FNA. This pause allows everyone to confirm that the correct procedure is performed on the correct patient and the correct lesion.

2.5.1 Palpation and Immobilization of the Lesion

The first steps in performing an FNA are palpation and immobilization of the lesion. Palpation is performed at the time of physical examination to investigate the size, mobility, contour and consistency of the mass, and presence or absence of associated tenderness. It is repeated prior to sampling primarily to confirm the location and accessibility of the lesion. Before proceeding with immobilization and sampling of the lesion, children who are developmentally unable to cooperate and are not under general anesthesia must be securely positioned with a nurse and/or parent helping to immobilize their arms and legs. If the child is strong or there are not enough people to assist with the procedure, then a papoose can be utilized to secure the child (Fig. 2.5). In some cases the FNA is performed under conscious sedation or general anesthesia at the request of the parent and/or discretion of the clinician. An ideal time to perform an FNA is when the child is undergoing general anesthesia for another procedure (e.g., FNA of an enlarged cervical lymph node during anesthesia for placement of myringotomy tubes) and can be optimally positioned with no movement; however, this is not an option in all cases. Once the patient is immobilized, the lesion itself can be immobilized with the fingers of the non-dominant hand, usually the index and middle fingers in order to reserve the thumb for stabilizing the needle and syringe holder. In young or anxious patients, topical anesthetic, such as 4 % topical lidocaine cream, can be applied prior to the procedure to decrease discomfort during the FNA and is typically tolerated better than subcutaneous injection of 1 % lidocaine with 1:100,000 epinephrine.

2.5.2 Performing the Fine Needle Aspiration

An FNA typically involves 3–5 needle passes with 22, 23, 25, or 27 gauge disposable hypodermic needles with long bevels. If aspiration is used, a syringe holder is helpful because it allows one to aspirate with one hand and stabilize the target with the other. Most syringe holders accommodate a 10cc syringe, which is easier to manage than those designed for 20cc syringes. Once the lesion is immobilized, the skin overlying the aspiration site is disinfected with an alcohol swab or iodine scrub. The needle is then inserted and a sweeping motion back and forth within the lesion is utilized for about 15 quick excursions or until material appears in the hub of the needle. FNAs can be performed with or without suction. A comparison of these methods is summarized in Table 2.1. FNAs utilizing suction are helpful for obtaining more abundant material for ancillary studies and for draining cystic lesions; however, the increased distance between the aspirating hand and the lesion limits the fine motor control and the size of the device may increase the patient's apprehension (Fig. 2.6). FNAs performed without suction (capillary method, Zajdela technique, French method, or "non-aspiration aspiration") usually yield less material, but the aspirates tend to be less bloody and relatively more cellular making it ideal for sampling highly vascular lesions, such as thyroid nodules (Fig. 2.7). This approach may also cause less anxiety for a young patient because the equipment is limited to a small needle, which is more modest in scale and can be hidden discretely in the operator's hand. It also offers better fine motor control because of the shorter distance between the lesion and the operator's hand. This makes it the optimal technique for sampling small, mobile lesions or lesions in non-sedated or anxious patients who are likely to move during the procedure.

Fig. 2.6 FNA performed with suction (Swedish technique). This FNA is performed with a syringe holder containing a 10cc syringe, which allows the operator to use negative pressure during the aspirate with one hand, while the non-dominant hand stabilizes the lesion and the patient.

Table 2.1 Comparison of FNA techniques with and without suction

	Fine needle aspiration without suction	Fine needle aspiration with suction
Other terminology	French, Zjadela technique, fine needle non-aspiration aspiration, capillary method	Swedish technique
Uses	• Vascular lesions • Small lesions • Lesions that are very mobile and require optimal fine motor control • Pediatric patients or anxious patients that are not under anesthesia	• Cysts • Cases requiring material for ancillary studies • Cases with low yield using non-aspiration techniques in order to try to obtain greater cellularity
Advantages	• Better fine motor control • Concentrated specimen with less blood (qualitative) • Absence of syringe holder may decrease anxiety for the patient	• Cystic lesions (to drain material) • Can obtain more material (quantitative)
Disadvantages	• Less material and potentially dry tap • Cannot drain a cystic lesion	• Greater chance of peripheral blood dilution • Less fine motor control • Syringe holder may create anxiety for patient

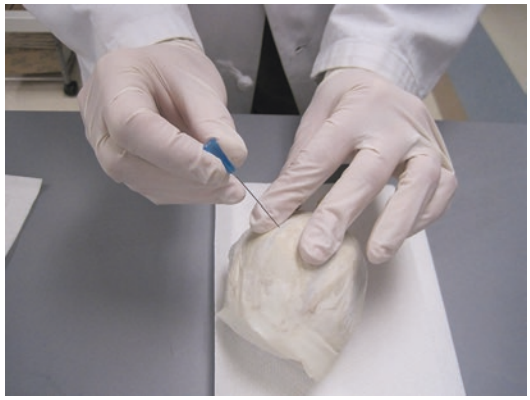

Fig. 2.7 FNA performed without suction (non-aspiration method). This FNA is performed with the needle only, without a syringe, thereby allowing for better fine motor control and possibly, decreasing the patient's anxiety.

2.6 Slide Preparation andTriaging Material for Ancillary Studies

After performing each pass, the aspirated material is expelled onto a labeled glass slide(s) using a syringe filled with air and is then smeared to create a monolayer or near monolayer of cells that can be stained and examined (Fig. 2.8). The smearing technique involves sliding a second clean glass slide on top of the slide containing the aspirated material. The preparation of optimal smears takes time and practice, as too much material on a slide results in a thick smear that is difficult to interpret, too much pressure may cause crushing of fragile cells, and improper fixation can lead to artifactual changes limiting the morphological evaluation (Figs. 2.9 and 2.10). If smears are to be alcohol fixed, then submersion in the fixative should be immediate to avoid air-drying artifact. Papanicolaou staining is superior for nuclear detail and to identify squamous cells. However, Romanowsky-type stains enhance nuclear pleomorphism due to slight nuclear enlargement with air-drying, and highlight background (extracellular) elements like mucin and stromal material. Romanowsky-type stains are usually preferred for rapid on-site evaluation in the pediatric setting because they are take less than a minute to perform and are especially useful for evaluation of lymphoid morphology and

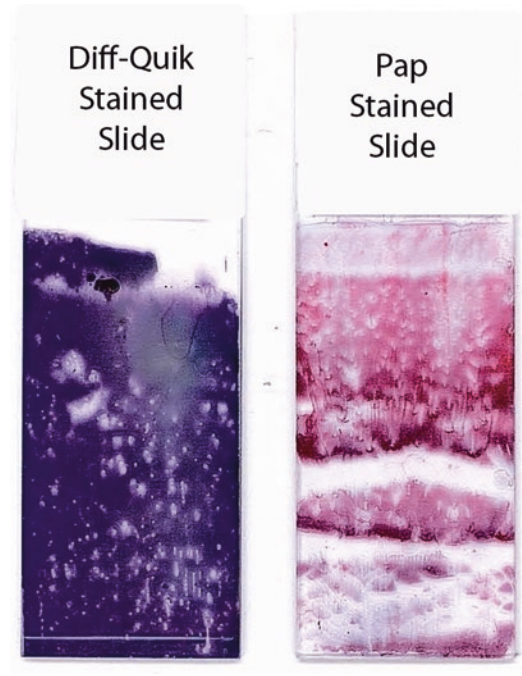

Fig. 2.8 Aspirate smears from FNA. Once material is aspirated, it is expelled onto a slide and spread into a monolayer or near monolayer for staining and evaluation with a variety of different stains.

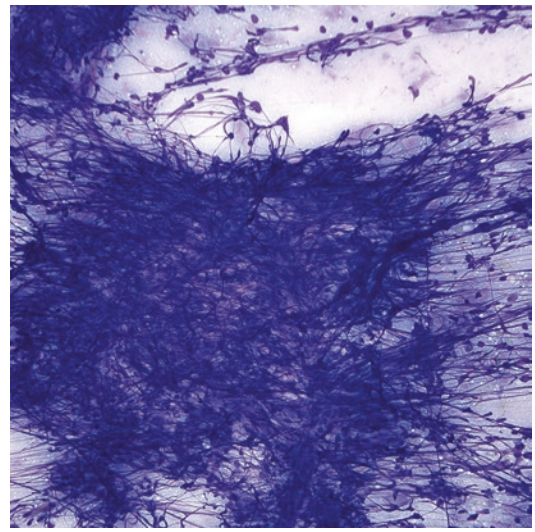

Fig. 2.9 Artifactual changes in lymphoid cells (Diff-Quik stain, medium power). The act of smearing and other preparation-related issues can cause crush artifact, which is most pronounced in fragile cells, such as lymphocytes, and this is sometimes called a "lymphoid tangle".

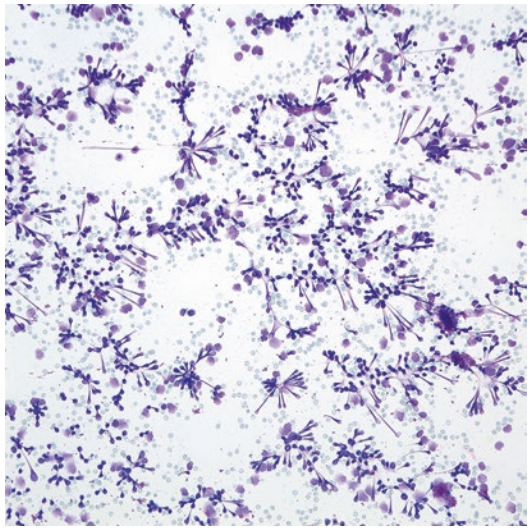

Fig. 2.10 Artifactual changes in lymphoid cells (Diff-Quik stain, medium power). The act of smearing and other preparation-related issues can cause artifactual changes, which are most pronounced in fragile cells, such as lymphocytes, and can make the cytological evaluation difficult.

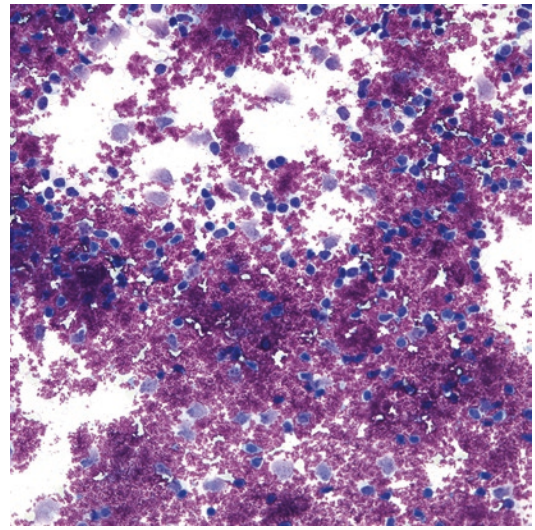

Fig. 2.11 Ultrasound gel artifact (Diff-Quik stain, high power). In ultrasound-guided FNAs, if there is residual gel on the needle that is not wiped off before smearing, the gel can appear as metachromatic, crystalline-like material that obscures the cells of interest.

discrimination of lymphoid proliferations from other small round cell tumors. In US-guided FNAs, the ultrasound gel can obscure the smears and make interpretation difficult (Fig. 2.11). Thus, wiping the excess gel from the needle prior to expelling the material can be helpful.

Following expulsion of material onto slides, the needles are rinsed in RPMI, phosphate buffered saline or a fixative such as formalin or CytoLyt™. RPMI and phosphate buffered saline allow eventual triage of material to flow cytometry and/or cytogenetics, as well as cell block preparation, and therefore, are suggested media for rinsing needle(s) prior to on-site evaluation. Following on-site evaluation, needles from additional and/or dedicated passes can be rinsed in the medium or media deemed most appropriate for triaging the specimen.

2.7 Documentation

At the conclusion of the FNA, the pathologist should complete, date, and sign a note documenting the procedure and, if performed, on-site evaluation. In addition, appropriate requisition form(s) should be completed and accompany the slides and any additional samples for ancillary studies. A sample intraoperative procedure note is presented in Table 2.2.

2.8 Post-procedure Laboratory Handling of the FNA Specimen

When the FNA procedure is complete, all slides and containers should be labeled clearly with at least two patient identifiers and the type of specimen (site and laterality). In addition, all paperwork should be completely filled out and signed in the appropriate places.

The material obtained by FNA typically includes aspirate smears that either need to be coverslipped (Romanowsky-type stained slides) or stained and coverslipped (alcohol-fixed slides). The needle rinses and/or the material obtained from dedicated passes for ancillary studies can be triaged in a variety of ways, depending on the differential diagnosis. For example, if a lesion yields

Table 2.2 Sample intraoperative procedure note for pediatric FNA biopsies

Pre-procedural information
Topical lidocaine cream was applied 30 minute prior to the procedure by the nursing team. The patient was seen and examined by _____. Physical examination: # cm lesion noted to be mobile/fixed, soft/firm, tender/non-tender, round/ill-defined, in the _____location. The potential risks of the procedure including infection, bleeding, bruising, and inadequate sampling with the possibility of additional diagnostic procedures were explained to the patient's parent/guardian by Dr._____. Informed consent was obtained from the patient's parent/guardian by Dr._____ and witnessed by _____. Assent was obtained from the patient.
Procedural information
A time out was performed prior to the procedure and documented by Dr._____. Procedure: FNAB, # passes with #G needle measuring # in. in length. # air-dried and # wet-fixed smears were prepared. Needles were rinsed in saline/RPMI/formalin [Free text for additional triaging of specimens]. Patient tolerated procedure well. No complications. The findings were communicated to and confirmed by the [Physician/Physician extender] at the conclusion of the procedure on [date] at [time]. Signature of physician performing the FNA, date, time.
Immediate On-site evaluation reporting
Date: mm/dd/yyyy Time stamp: hh:mm Part #, Pass # Site, Laterality, Procedure: A. Adequacy determination: Adequate/Less than optimal/Inadequate B. Primary Interpretation: Non-diagnostic/Benign/Defer/Malignant C. Free text D. Reason for terminating procedure: Adequate material obtained/Other. The findings in this case were communicated to and confirmed by [Physician/ Physician Extender] at the conclusion of the procedure on [date] at [time]. Signature of physician performing the on-site evaluation, date, time.

Fig. 2.12 FNA with suppurative material from a patient with a soft tissue abscess. The material aspirated is thick, turbid, yellow pus from the site of infection, and can be triaged for microbial cultures and determination of antibiotic sensitivities.

suppurative material, then material is usually reserved in sterile tubes to be sent to microbiology for culture and antibiotic sensitivities (Fig. 2.12). Needle rinses from worrisome hematolymphoid proliferations can be sent for flow cytometry to immunophenotype the cells, establish clonality, and aid in subclassification of a hematolymphoid malignancy. Cell blocks can also be prepared from residual material and can be used for hematoxylin and eosin-stained slides, special stains, immunostains, or molecular studies. Liquid based cytology (LBC) preparations, such as ThinPrep™ and SurePath™, are helpful for hypocellular aspirates, bloody aspirates, and cyst fluids in order to maximize the cellular yield and decrease obscuring blood. Hypocellular cyst aspirates in children can be difficult to classify without the presence of cyst lining cells, and LBC can be very helpful in these scenarios (Figs. 2.13 and 2.14).

2.9 Final Interpretation

After review of the slides and results of ancillary studies, a diagnosis is rendered and verified by the pathologist. It is important to correlate the results of ancillary studies with the morphological findings

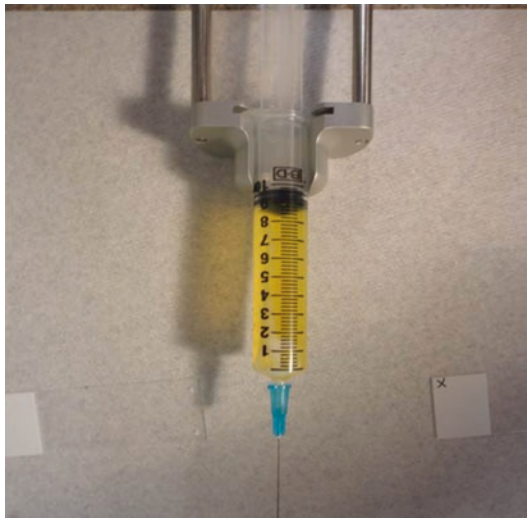

Fig. 2.13 FNA of cyst contents from a cystic neck mass. The fluid aspirated from this cystic lesion is translucent and yellow. These tend to be very hypocellular, and the use of liquid based cytology may improve the ability to concentrate the specimen and identify cyst lining cells.

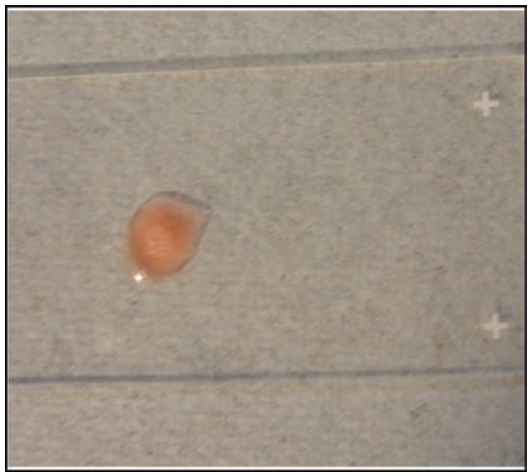

Fig. 2.14 FNA material from a branchial cleft cyst. Aspirate material from a branchial cleft cyst is expelled onto a slide and appears more watery, thin, and translucent than the suppurative material seen in Fig. 2.12.

to arrive at a definitive cytologic diagnosis or, when that is not possible, a differential diagnosis and to provide the referring clinician with as much information as possible. Furthermore, when the pathologist renders a diagnosis of a malignancy or other neoplasm, it is helpful to discuss the case directly with the referring physician in order to ensure that he or she receives the results in a timely fashion and is able to expedite notification of the family.

2.10 Conclusions

The approach to FNA in the pediatric population differs from that in adults, as highlighted in this chapter. Awareness of special considerations, including obtaining consent for an FNA, approaching the patient in a way that minimizes anxiety, and establishing appropriate immobilization of the patient, can help to maximize the success of a pediatric FNA. As illustrated, cytological material can be utilized for almost any ancillary study, and thus, knowledge of the differential diagnosis and what testing is required to arrive at a diagnosis are critical for optimizing one's yield from these procedures.

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