Pediatric Nuclear Medicine, Part II: Common Procedures and Considerations

Tonya A. Veitch

Nuclear Medicine Department, Children's Hospital, Birmingham, Alabama

Objective: This paper introduces technologists to pediatric nuclear medicine applications as well as serves as a review of the principles of pediatric imaging for more experienced technologists. After reading this article the nuclear medicine technologist should be able to: (a) identify pediatric populations commonly evaluated with nuclear medicine procedures; (b) state the indications for performing pediatric nuclear medicine procedures; and (c) discuss strategies and tips for performing nuclear medicine procedures on pediatric patients.

Key Words: pediatric patients; nuclear medicine procedures; indications

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Different procedures and strategies are needed for pediatric nuclear medicine, as compared with adult nuclear medicine, based on physiologic differences between children and adults. Some procedures are performed rarely outside of the pediatric setting, while other procedures vary from those performed on adults only in the amount of radiopharmaceutical administered. It is beyond the scope of one paper to present every aspect of pediatric nuclear medicine. As with all procedures, the needs of each department vary according to such things as the volume of studies performed and the patient populations served. This paper introduces the nuclear medicine technologist to some of the unique needs of pediatric patients and their families.

PATIENT PREPARATION AND SCHEDULING

Patients and families need to be prepared for the nuclear medicine procedure that has been ordered. Correct patient preparation instructions need to be clearly communicated to the patient. For pediatric patients, this communication often is given to the parent(s) or other care provider(s). It is also important to explain the study. An outline or timeline of the procedure is helpful. Inquire about other appointments and/or studies the patient will be having on the same day. Help the patient and family plan their visit by preparing them for both the nuclear medicine procedure and for the amount of time they will need to be at the facility. In some cases it may take several hours to complete all scheduled appointments.

When scheduling a pediatric procedure, allow extra time to complete the procedure. Many things can happen to delay the start of a procedure or extend the amount of time needed to complete it. Examples of situations that can disrupt a tight schedule are difficulty starting an intravenous line in an infant, a fussy child who does not want to drink fluids as required for a gastric emptying study, a shy or nervous child who does not want to undress for a voiding cystourethrogram, or a decision to sedate a child. It is important to remain flexible while keeping as close to the schedule as possible. Children who have not been able to eat may not understand why they cannot have food and prolonging the time that they cannot eat may make them more unhappy. Children can become scared, nervous or even bored the longer they wait or the longer the procedure takes. Unhappy children tend to make their parents unhappy also. Clear and calm communication between the nuclear medicine staff and the patient and family is essential.

PEDIATRIC RADIOPHARMACEUTICAL CALCULATIONS

The normal adult activity is a critical value in all pediatric activity calculations. Each department must choose the defining criteria and calculate it consistently. Some departments select 15 y as the defining age for an adult. Others use a patient weight of 65 kg as the defining criterion. Some choose 56 kg or 57 kg for women and 70 kg for men (*1,2,3*). Each department also needs to select and use one method for calculating the amount of radiopharmaceutical to be administered to pediatric patients that works best for their department. The routine calculations use the patient's age, body weight or body surface area to calculate the amount of activity to be administered to a pediatric patient. Table 1 provides sample calculations based on several formulas.

Sometimes the calculated activity is not sufficient to obtain quality images and sometimes the calculated activity is not consistent with radiation dosimetry limits. Pediatric radiopharmaceutical calculations can be a test of judgement. Nuclear medicine departments should have the flexibility in their

For correspondence or reprints contact: Tonya A. Veitch, Children's Hospital Pediatric Imaging, 1600 7th Ave. South, Birmingham, AL 35233.

TABLE 1
Sample Pediatric Radiopharmaceutical Calculations

A 2-y-old boy weighing 30 lb enters the department for a dynamic renal function study. The maximum recommended adult dose for the same procedure is 10 mCi.

2-yr-old	Adult
30 lb = 13.6 kg	70-kg man; 56-kg woman (*3*)
Body surface area = 0.53 m^2 (*3*)	1.8 m^2 man; 1.6 m^2 woman (*3*)
Organ weight of 2 kidneys = 93 g (*3*)	Organ weight of 2 kidneys = 310 g (*3*)
Young's Rule (*5*)	
$\frac{\text{Child's age (y)}}{\text{Child's age (y)} + 7} = \frac{2}{2+7} = \frac{2}{9} = 22\%$	22% of 10 mCi = 2.2 mCi
Modified Young's Rule (*5*)	
$\frac{\text{Child's age (y)} + 1}{\text{Child's age (y)} + 7} = \frac{2+1}{2+7} = \frac{3}{9} = 33\%$	33% of 10 mCi = 3.3 mCi
Clark's Rule (*4,5*)	
$\frac{\text{Child's weight (kg)}}{\text{Adult's weight (kg)}} = \frac{13.6}{70} = 19\%$	19% of 10 mCi = 1.9 mCi
Using body surface area (*4*)	
$\frac{\text{Child's body surface area (m}^2\text{)}}{\text{Adult's body surface area (m}^2\text{)}} = \frac{0.53}{1.8} = 29\%$	29% of 10 mCi = 2.9 mCi
Using organ weight (*5*)	
$\frac{\text{Target organ weight of child (g)}}{\text{Target organ weight of adult (g)}} = \frac{93\text{ g}}{310\text{ g}} = 30\%$	30% of 10 mCi = 3.0 mCi

radioactive materials license to allow for adjustments based on the assessment of an individual patient's needs. For example, a 2-kg, 28-wk premature infant or a 113-kg, 12-y-old child may need individualized radiopharmaceutical prescriptions. Other considerations that may require individualized prescriptions include the presence of an indwelling venous port system, which can absorb some tracers, the need to evaluate small targets in small patients, such as a cuboid bone in an infant or small child, or the need for higher resolution images, such as those obtained with a pinhole collimator or by SPECT imaging.

IMMOBILIZATION AND SEDATION

Immobilization of a patient to perform a medical procedure often is differentiated from restraint. It is important that the nuclear medicine staff know and follow the institutional policies and procedures related to immobilization, restraint and sedation.

Be certain that the parent(s) or guardian(s) is aware of the plan to immobilize the patient if immobilization is necessary and that they give their verbal consent. Immobilization of pediatric patients requires both skill and patience. Cloth tape, swaddling and bundling with sheets are examples of materials that work well to immobilize children. Other immobilization devices include vacuum pillows, papoose boards and imaging chairs. Most children protest only when they realize that their movements have been restricted. The nuclear medicine technologist can ease a child's fear and increase cooperation by releasing the areas that have already been imaged, such as the feet during a bone scan, or areas that are not being imaged as a part of the procedure, such as the head and arms during a gastric emptying study.

Sedation of pediatric patients to perform a procedure requires signature informed consent by the parent(s) or guardian(s) for the sedation (in addition to consent for the procedure), certain presedation assessments of the patient, and other institutional requirements. The sedated patient who is undergoing a procedure must be monitored at all times by an individual who has documented sedation monitor competencies. The sedation monitor's only task is to monitor the sedated patient until the patient meets the criteria for transfer or release. It is important that the nuclear medicine department provide the same level of sedation care as all other departments within an institution.

INJECTIONS

Although no child likes needles, injections or intravenous lines, nuclear medicine technologists must perform the intravenous injection of radiopharmaceuticals. This is the only method by which many radiopharmaceuticals can be administered. Placing an intravenous line with a heparinized injection port is often the best choice for pediatric patients who are scheduled for admission, for multiple procedures that require intravenous injection(s) including contrast materials and radiopharmaceuticals, or who will undergo intravenous conscious sedation.

Parents are likely to approve of the placement of an intravenous line rather than have their child undergo several separate injections. It is also prudent to determine if laboratory tests that require blood samples have been ordered. If the nuclear medicine staff is placing an intravenous line, blood can be collected at that time, before heparin or saline has been injected. This also will reduce the need for additional needle sticks to the patient.

Some children have indwelling port systems in place for intravenous access. Ports are generally easy to access and they make intravenous injection simple. Most institutions require, by policy, in-house training on how to access these devices, as keeping the port devices viable is not a simple matter. Most patients with these ports are receiving chemotherapy or antibiotic therapy. Chemotherapy patients generally are immunocompromised. Antibiotic therapy patients generally have suffered a serious infection. Sterile procedures always should be followed for any intravenous injection. Injections into an indwelling port system, however, require special vigilance. Infections acquired through a port easily can become systemic and carry the risk of being life threatening for chemotherapy patients and patients already receiving antibiotic therapy. In addition, the port itself may become infected and this may require removal or replacement of the port device.

POSITIONING

Positioning children for nuclear medicine procedures can be both a blessing and a burden. More of the body can be imaged at one time because children are smaller than adults. This usually results in a shorter total imaging time for a child as compared with an adult. Smaller bodies also mean smaller targets and small targets can be more difficult to image adequately. To illustrate this point, it is crucial to position children properly for bone imaging. The patient's toes must be pointed inward and the heels outward to separate the tibia and the fibula. This is important in children being evaluated for osteomyelitis of the ankle. The hands must be positioned flat and preferably supine to differentiate the ulna and the radius. The hips must be positioned symmetrically to correctly evaluate the sacroiliac joints for osteomyelitis and the femoral heads for Legg-Calvé-Perthes disease.

Positioning may be easier said than done in young or unhappy patients. It is helpful to acquire images with the gamma camera out of sight when possible. For example, posterior images generally are acquired with the gamma camera head under the patient. When images are not being acquired, keep the gamma camera out of sight or move the child away from the camera whenever possible to avoid frightening the child. However, keep the child on the imaging table until the nuclear medicine physician has reviewed the completed study. If the child did not want to cooperate for the initial images, it is unlikely that they will cooperate for any needed additional images, especially if the child has been allowed off the imaging table. Always remember to communicate to the parents why the child must remain on the imaging table.

VOIDING

A patient's ability to void is not a concern in most cases when performing nuclear medicine procedures on adults. Voiding on demand may be impossible in young children who have not been toilet trained. It may be difficult to achieve even in those who have been toilet trained. Young children may not cooperate or may not be able to effectively void. Preschool children may be too nervous or too willful to void when asked. Sedated children may not feel the urge to void or may have temporarily lost the ability to void. Urinary catheterization may be required.

Children who are capable of voiding should do so before any lengthy imaging procedure or procedures that include images of the pelvis. The classic example is having all patients, including pediatric patients, void immediately before acquiring delayed bone images. Other pediatric nuclear medicine procedures for which patients should void before imaging include Meckel's diverticulum studies, gastrointestinal bleeding studies, gallium imaging, and gastric emptying studies. Having the patient void before long imaging procedures will improve patient comfort and increase the chances that the study will not be interrupted. Prestudy voiding also removes an excuse from an anxious child who may want to stop the procedure being performed.

Urinary catheterization only should be performed at the direction of the nuclear medicine physician. Some institutions allow nuclear medicine technologists to insert urinary catheters and others do not. Each technologist should know local policy and procedures. Sterile technique must be followed strictly during urinary catheterization to prevent introducing an infection. Patients who are immunocompromised, such as patients who are receiving chemotherapy, require careful evaluation before urinary catheterization. White blood cell and platelet levels should be checked to determine if a urinary catheter should be inserted. If the platelet levels are too low, the insertion of the catheter could result in unusual blood loss.

The smallest diameter catheter feasible should be used if urinary catheterization is required. Nonlatex catheters are the best choice for use in children based on the rising rates of latex allergies in patients and caregivers. An 8-French feeding tube is sufficient for most children. Some premature infants require a 5-French catheter. Each patient and each situation requires evaluation and the use of judgement in selecting the proper catheter. A 12-y-old with severe hydronephrosis and bilateral megaureters required a 10-French catheter for sufficient drainage. Again, sterile procedure is paramount to prevent nosocomial infections.

A child can be traumatized by repeated attempts at catheterization and delicate anatomy can be injured. If there is any difficulty or if there are any concerns, the nuclear medicine physician or the patient's referring physician should be consulted. The nuclear medicine staff may encounter developmental anomalies, such as epispadias and hypospadias, which are more common in boys, but they are possible in girls as well. Girls may have labial adhesions. Ambiguous genitalia may be encountered infrequently.

Children may be undergoing monitoring of their intake and output. These are commonly referred to as "I+O" orders. The nuclear medicine staff should be aware of these orders if they are present, as all intake and output of fluids must be reported to the nursing staff. For example, soiled diapers must be kept for weighing if an infant is being monitored. All urine resulting from a catheterization also must be measured and reported if a patient is being monitored.

CRYING AND PAIN

When a urinary catheter is inserted, a 2-wk-old infant will whimper and cry and soon fall asleep. A 5-y-old child usually will scream when a urinary catheter is inserted and continue to say it hurts during and after the procedure being performed. The difference in response seems to be related to the amount of knowledge the child has about the procedure(s) being performed and, in this example, is related to the amount of control the child has over the muscles involved. It is important to realize that a child's actions in response to and perspectives about what is happening to them may be sources of their distress. The nuclear medicine technologist must explain the procedure(s) and try to calm the child. In this way the technologist serves as a support figure for the parents by helping the child relax or hold still during a procedure or injection.

Children often think in concrete terms. Bath water is either hot or cold. Food is good or bad. The catheter or needle hurts or does not hurt. It is difficult for them to think in terms of lukewarm, tolerable or uncomfortable. New or unexpected sensations that are not immediately identified as pleasurable may elicit crying. The nuclear medicine technologist must realize that not all crying is caused by intractable pain. Children use crying to express an array of emotions that they do not fully comprehend. Most children will cry. Some children cry in response to fear, pain, hunger and being tired. Screaming without tears is usually for attention, or out of anger. The technologist must discern the source of the crying or screaming and try to eliminate the source if possible.

INFECTION CONTROL

Children are well known for contracting and transmitting various infections and diseases. The standard procedures for hand washing between patients, using fresh linen for each patient, and practicing universal precautions should be second nature for all health professionals. It is best to use disposable supplies or items that can be laundered and/or sterilized after each use when working with children. Using sheets and towels to make padding or cushions prevents the spread of infection between patients from nondisposable items such as pillows. Chemotherapy patients who may be immunocompromised should be somewhat isolated from other patients for their own safety. Arrange for these children to come directly into the imaging room, rather than waiting with other patients in the waiting room.

PEDIATRIC NUCLEAR MEDICINE PROCEDURES

Bone Imaging

Common indications for bone imaging in children include evaluating orthopedic pain or the refusal of a child to use a limb, and ruling out an occult fracture. Other pediatric indications for bone imaging include evaluating Legg-Calvé-Perthes disease, evaluating an osseous lesion seen by radiograph, and identifying the location(s) of an osseous tumor or metastatic disease.

Patient hydration must be coordinated with caregivers and other scheduled procedures. It is desirable for patients who are undergoing bone imaging to be well hydrated, but this may not always be possible. Sedation may lessen the feeling of urinary urgency and patients who have been well hydrated must void before bone imaging, especially if pelvic imaging is required.

Start an intravenous line if admission to the hospital is likely. It is often easier to perform a flow study, for example, through an indwelling intravenous line. Indwelling port systems may be used to administer the radiopharmaceutical but they must be flushed generously with saline afterwards. The access lines should be positioned outside the field-of-view or away from bony structures whenever possible.

Osteomyelitis is the most common indication for performing a 3-phase bone imaging study in pediatric patients. These patients usually present with a limp, pain and fever, and they are generally in the 2- to 5-y age group. These young patients must be immobilized to obtain high-quality images. These patients are often in pain and it is difficult for them to hold still without immobilization.

Reflex sympathetic dystrophy (RSD), which also is known as reflex neurovascular dystrophy (RND), is another indication for performing a 3-phase bone imaging study. These patients are usually teenagers. Many of these patients have a long history of pain, usually after a trauma event. This condition occurs when the inflammatory response sends a biofeedback message to stop the increased blood flow to the affected area. The bone flow study shows less perfusion at the affected site when compared to the normal contralateral side.

Bone SPECT procedures are indicated for patients who are being evaluated for osteoid osteoma of the spine, patients with scoliosis, and to evaluate sports-related injuries in patients with spondylolysis. Patient size and cooperation determine the SPECT technique to be used. For example, the time per stop can be increased for cooperative patients. Lying still for a SPECT procedure might be painful. Pain medication, if given, should be given early enough to provide pain relief for the patient during the procedure. Placing cushions under the patient's knees can greatly improve the comfort of the patient. Padding the SPECT table also may improve comfort. A moving machine that is close to a child can be frightening. Adjust the distance between the camera and the child as close as possible.

Brain Imaging

Brain SPECT imaging is performed on children to locate a seizure focus or to determine a baseline for comparison with future ictal studies. Imaging procedures for patients with seizure disorders must be coordinated with other caregivers and modalities, such as EEG and telemetery, especially if ictal studies are performed. The nuclear medicine license may need to be amended to allow administering radiopharmaceuticals in patient rooms for ictal imaging. The seizures may require that the patient be sedated. Sedation also may be needed to reduce patient motion during imaging. Sedated patients must be monitored at all times according to institutional policy.

Gastric Emptying and Gastroesophogeal Reflux Studies

Patients who present with gastroesophogeal reflux (GER), vomiting, failure to thrive (FTT), abdominal pain, asthma and/or wheezing may need a gastric emptying study. Gastric emptying studies also are used to evaluate fundoplasty and fundoplication. Gastric emptying studies should be scheduled to allow delayed imaging at 6 h and 24 h if needed. Coordination is required to ensure that barium studies, such as a gastrointestinal series or barium swallow, are performed after the nuclear medicine gastric emptying study. The presence of barium interferes with a gastric emptying study. Coordination also is required for pH probe placement in these patients and to maintain the correct feeding status (i.e., nothing per mouth).

An external suction device must be available during the procedure in case suction is needed. Some patients have gastrostomy tubes in place. These patients must bring their tubing supplies and their normal formula with them for the procedure. Some patients may require the temporary placement of a nasogastric tube if they cannot or will not cooperate, depending on the importance of the examination results.

Gallium Imaging

Gallium imaging studies often are used to locate soft tissue tumors, soft tissue metastatic disease, and the sources of fever of unknown origin. If ^{67}Ga is administered through an indwelling port system, the port must be flushed generously with saline afterwards. The port access lines must be located outside the field-of-view during imaging if possible. Gallium studies should be scheduled to allow delayed imaging at 6, 24, 48 and 72 h as needed. Bowel excretion of gallium is as problematic in children as it is in adults. Certain foods, such as apple juice (not diluted), may be a better choice than laxatives or enemas for infants and toddlers, and apple juice generally provides a good result in young children.

Gastrointestinal Bleeding Studies

Gastrointestinal bleeding studies should be scheduled to allow delayed imaging as needed, especially when active bleeding is suspected. The patients should void before imaging. A dynamic flow study is performed initially, followed by an anterior static image and a lateral image.

Meckel's Diverticulum Localization

The presence of blood in the stool is the most common symptom that results in a Meckel's diverticulum localization procedure. Pentagastin can be used to increase tracer uptake in this procedure. Coordination is required to ensure that barium studies are performed after the nuclear medicine Meckel's diverticulum study. The presence of barium interferes with a Meckel's diverticulum study. When planar images fail to localize a Meckel's diverticulum and the suspicion that one is present, SPECT imaging should be performed in addition to the planar study (*6*).

Liver and Gallbladder Functional Imaging

Biliary atresia is the most common reason for performing liver functional imaging in newborns. Older children who suffer postprandial pain also may need liver and gallbladder functional imaging. Children with biliary atresia should have phenobarbital for 5–7 d before imaging (*2*). Hepatobiliary imaging studies should be scheduled to allow delayed imaging at 4 h and 24 h as needed. Morphine sulfate is used sometimes in children, as in adults, to facilitate gallbladder filling. Gallbladder ejection fraction studies classically are done using cholecystokinin to induce gallbladder contraction. A fatty meal also induces gallbladder contraction and may simulate the effects seen after eating.

Cardiac Blood-Pool Imaging

Monitoring cardiac function is necessary in some chemotherapy patients due to the cardiotoxicity of some chemotherapy agents. Both echocardiology and nuclear medicine procedures can be used to follow these patients. Younger children who are unable to remain still for the nuclear medicine procedure may be better followed by echocardiology. The same is true for patients with irregular heart rates.

Each nuclear medicine department must select the radiopharmaceutical they will use to perform blood-pool imaging in children. A patient's red blood cells can be labeled using either an in vivo or an in vitro technique. Some literature suggests that some chemotherapy agents may decrease red blood cell labeling efficiency (*7*). Labeled human serum albumin also can be used as a blood-pool imaging agent and it offers the advantage in children that only one injection needs to be made. Indwelling port systems may be used to administer the radiopharmaceutical, but they must be flushed generously with saline afterwards. The access lines should be positioned outside the field-of- view whenever possible.

Renal Imaging Studies

Ideally patients should be well hydrated before renal imaging. This may not always be possible, however. Hydration orders must be made in coordination with clinical care staff and based on the evaluation of each patient. Static renal imaging is performed on children with vesicoureteral reflux (VUR), urinary tract infections (UTI), hypertension or cystic kidney diseases. Static functional imaging can document renal scarring, acute pyelonephritis and differential renal function.

Dynamic renal functional imaging is indicated for evaluating an obstruction in hydronephrosis, megaureters, or when an obstruction is known to be present. The evaluation of renal function in cystic kidney disease, hypertension, after kidney transplant, and pyeloplasty also is performed using dynamic renal functional imaging. Some renal function protocols specify that a urinary catheter be placed and that furosemide be administered to the patient. If the patient also is having a voiding cystourethrogram (VCU), the VCU should be performed before the renal function protocol for two reasons. First, it allows the urinary catheter placed for the VCU to remain in place, avoiding a second catheterization. Furosemide administration, as a part of a renal function protocol, might increase renal clearance to such a degree that a low-grade reflux might be missed inadvertently on a VCU. Older patients with more urinary control might be able to avoid catheterization for renal imaging because they are able to void before imaging and void again near the end of the study for postvoid images.

Voiding Cystourethrogram

Children are routinely referred to nuclear medicine for a voiding cystourethrogram to identify urinary reflux after a first or second UTI. This commonly occurs around 2 or 3 y of age. Children are toilet training at this age. Some children begin having UTIs as early as 2–3 mo of age. Children who are younger than 1 y have small urinary bladder volumes that can lead to highly variable and even misleading VCU results. In these infants it is appropriate to image 2 or 3 cycles of filling and voiding without repeating the catheterization.

These children routinely have renal ultrasound performed in addition to the VCU. The child must be fasting before the renal ultrasound, which should be performed before the VCU. This allows the patient to eat and drink before the VCU, which comforts the child before the procedure.

The VCU is perhaps the most difficult nuclear medicine procedure for the pediatric patient to endure. It is also the least accommodating to sedation. Sedation probably takes longer than the VCU procedure and sedation could interfere, resulting in erroneous results. Stress might improve the chance that reflux might occur during imaging. If sedation is required to perform the study, light sedation methods are best. The pediatrician can provide the parents with several options if needed.

The parents need to be a source of comfort and security for their child during a VCU procedure. The child should be allowed to hold a favorite toy or object. Games, songs or television should be used to provide distraction during the procedure to make it as easy as possible.

Thyroid Imaging

Newborns with abnormal thyroid profiles and teenagers with thyroid nodules are the two most common pediatric referrals for thyroid imaging. Sodium pertechnetate is the radiopharmaceutical of choice for initial thyroid imaging in children. When imaging patients with congenital hypothyroidism, a planar image of the abdomen should be acquired in addition to standard views. Ectopic thyroid tissue has been found as low as the ovaries (*8–11*). It is sometimes helpful to acquire a background image over the leg to help discern the degree of hypothyroidism or hyperthyroidism.

Labeled White Blood Cell Imaging

Labeled white blood cell imaging procedures are performed to evaluate known or suspected infections and to locate sources of fever of unknown origin. Labeled white blood cell imaging studies should be scheduled to allow delayed imaging at 6 h and 24 h as needed. The largest gauge intravenous line practical with a heparin lock should be placed to avoid multiple needle sticks.

PEDIATRIC POPULATIONS

Chemotherapy Patients

The main points to remember when working with children who are receiving chemotherapy have been stated in detail previously. These patients may be immunocompromised making it important to reduce exposure to potential infections. If indwelling port systems are in place, they can be used to administer radiopharmaceuticals to reduce the number of needle sticks to the child. These patients can be highly sensitive to smell (alcohol, iodine) and taste (injected heparin and saline). Be prepared to work quickly and have gum or mints available to reduce the taste.

Renal Patients

It is notoriously difficult to start intravenous lines in patients who have renal failure or who are on dialysis. These patients may have a shunt in place, but only specially qualified personnel are allowed to access these shunts. If hydration is desirable, as for renal or bone imaging procedures, it is important to discuss this with the patient's clinician. Sometimes it is desirable to have the patient undergo dialysis after the imaging procedure is performed. This is especially true if contrast has been administered.

Cerebral Palsy Patients

Patients with cerebral palsy (CP) exhibit the entire range of mental and physical ability (*12*). Some patient's symptoms are unremarkable. Others have speech impediments, retardation, and loss of motor control to varying degrees. The nuclear medicine technologist must work with the parents to communicate with the child while transferring and positioning the child. These patients tend to be nervous and easily frightened. The technologist should expect to spend time calming and comforting children with CP.

Positioning may be difficult depending on the degree of loss of motor control. Immobilization may be needed. Some CP patients may be able to straighten their limbs, but unable to keep their limbs from involuntarily contracting to their usual position. Some patients may be combative and require sedation.

Patients without complete bladder control use adult diapers or their parents may catheterize them. Intravenous access may be difficult. More severe cases often have had fundoplication or gastrostomy placements. Gastric emptying studies and hepatobiliary function studies are commonly performed on CP patients.

Cystic Fibrosis Patients

Cystic fibrosis (CF) is a condition that can affect several organ systems. Lung secretions are not broken down and digestive enzymes are lacking (*13*). Lung scans and hepatobiliary function studies are performed commonly on CF patients. Fasting must be kept to a minimum as CF patients require high-calorie diets.

Spina Bifida Patients

Spina bifida is a neural tube defect that can occur anywhere on the spine. These patients are usually wheelchair-bound and have little mobility of their legs (*12*). Patients with neurogenic bladders may catheterize themselves (*5*). Every spina bifida patient should be questioned about having a latex allergy as this is common in this group of patients (*13–16*). The nuclear medicine department needs to be prepared by having nonlatex gloves, tourniquets, and other supplies available for use.

Diabetes Patients

Fasting should be minimized also for pediatric patients with diabetes. Intravenous access may be difficult, but injections or placement of an intravenous line in the foot should be used only as a last resort.

Nonaccidental Trauma Patients

Unfortunately, cases of nonaccidental trauma, better known as child abuse, are an unavoidable part of pediatric nuclear medicine. Battered children are seen most commonly in nuclear medicine for bone scans to evaluate old or unknown bone fractures. Neglected infants and toddlers who exhibit symptoms of failure to thrive may be evaluated by gastric emptying studies.

Abused children are very sensitive to changes in their environment. They may be emotional and difficult to comfort or calm. Nuclear medicine technologists must create a sense of safety. This can be done by slow and nonthreatening movements combined with gentle gestures, talking or touching.

Burn Patients

Health professionals who work with patients with serious burns must be specially trained and qualified. The nuclear medicine technologist should not attempt to remove any dressings or appliance without permission from the patient's physician. Some dressing changes require strict sterile technique with special cream formulations. Only qualified personnel should perform any dressing procedures.

Sickle Cell Disease Patients

Patients with sickle cell disease are referred to nuclear medicine for bone or bone marrow imaging, often to evaluate bone pain. Intravenous access may be difficult if the patient has had multiple sickle cell crises. A patient having a sickle cell crisis is often in extreme pain and morphine is frequently given in this case. Nuclear medicine staff must coordinate with other care givers to ensure the patient can void before the study. Morphine can cause the loss of urinary urgency or control.

Attention Deficit Disorder Patients

Performing a nuclear medicine procedure on a patient with an attention deficit disorder (ADD) or an attention deficit hyperactivity disorder (ADHD) can be challenging. Fasting should be minimized because, with nothing to swallow, these patients may skip their medications. These patients need to be kept distracted with television or by other techniques. Boredom can quickly turn to frustration and then to anger.

SUMMARY

Performing nuclear medicine procedures on pediatric patients is varied and rewarding. No two examinations are alike. The condition of each patient, the patient's ability to cooperate, the parents, the demands of the nuclear medicine procedure and other scheduled procedures combine to create unique situations. The nuclear medicine technologist must be ready with alternatives and options for every step in a protocol.

Working with children requires the ability to make quick assessments of a patient's psychological, mental and emotional states, as well as patience and understanding. Being able to explain the procedure and to comfort a child is appreciated also by the parents. Working with children can be a challenge if the child becomes tired, hungry, unhappy or frustrated. The nuclear medicine technologist must strive for a technically good study, a happy patient, and satisfied parents. Achieving this result is rewarding.

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