Teaching Editorial

Radionuclide Cystography

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Direct radionuclide cystography (RNC) is now a well accepted technique in nuclear medicine practice. After much effort, the technique has been added by the Food and Drug Adminstration to the list of indications in the package insert for technetium-99m (^{99m}Tc)-pertechnetate (*1*). This alternative to the x-ray cystogram has several major advantages that warrent its routine use not only in the follow-up examination of children with vesicoureteral reflux (VUR) but also as the primary examination in select groups such as children with meningomyelocoele or in females with urinary tract infection.

The advantages of RNC include a very low absorbed radiation dose to the child's gonads (*2*). It has been estimated that the ovaries receive less than 30 mrem while the testes absorb less than 5 mrem per exam (*3*). An even smaller absorbed dose can be attained by technique modifications (*4*). A low absorbed radiation dose is an important consideration in those children who are subject to multiple radiologic examinations because of their underlying urinary tract disorder. Another consideration is the high sensitivity of RNC for detecting VUR. Several studies have shown that RNC is at the very least comparable to x-ray cystography (*3,5,6*), while others have reported a greater sensitivity for detecting reflux (*7,8*).

More important, like most nuclear medicine procedures, RNC allows quantitation of data providing unique and accurate information that has been shown to correlate with spontaneous cessation of VUR (*9*). The bladder volume at which VUR occurs increases with each subsequent examination in those children in whom reflux will disappear spontaneously. The urologist therefore has a method at his command that readily differentiates those children who need surgery from those who can be treated with more conservative means. Other important information about bladder function is easily determined, including the total bladder capacity which has been shown to be predictive of specific bladder abnormalities, the reflux drainage time (*3*), the residual bladder volume, and if desired, the actual volume of reflux into the kidney (*10–12*).

A grading system of VUR can now be objectively determined rather than subjectively estimated as in x-ray cystography (*5,10–12*). Further information can be gained by simply recording pressures during filling of the bladder, a procedure termed the radionuclide cystometrogram (RNCMG) (*13*). The regular cystometrogram is a procedure frequently performed in surgery and often under general anesthesia, whereas RNCMG is performed as an outpatient procedure. With the RNCMG, bladder pressure measurements often are expressed as recognizable graphic patterns that correlate with specific bladder disorders. Therapy can thus be tailored to the specific disorder.

The major clinical indication for RNC is essentially its use in any child with urinary tract infection. Urinary tract infection (UTI) is common in children and especially in girls. Importantly, UTI and VUR are associated with loss of renal function. This can be very insidious with few symptoms or signs. Thus, the presence of VUR is suspected and must be documented in children in UTI. Ordinarily, x-ray cystography is requested as the initial exam because anatomic abnormalities are better depicted with x-ray than with RNC. The advantages of RNC, however, mandate its use in the follow-up examinations of such patients.

More recently, RNC has been advocated as an initial study in children who have a high incidence of VUR, for example in infants with meningomyelocoele (*14*), or as a screening technique in siblings of children with VUR (*15*). The RNCMG is indicated in children with voiding dysfunction and functional bladder disorders.

Radionuclide cystography can be performed in any nuclear medicine facility that has a scintillation camera. A computer is not essential. In fact, one only needs a persistence oscilloscope and a simple image recording device. The procedure is relatively simple and can be accomplished in less than 60 min with a cooperative patient.

The purpose of this paper is to describe the role of the nuclear medicine technologist in the performance of RNC and RNCMG. The responsibilities of the technologist can be significant, especially if she/he is trained in the technique of catheterization. Catheterization can be a simple and atraumatic experience for the child if performed properly. Conversely, both physical and psychological trauma can occur if the

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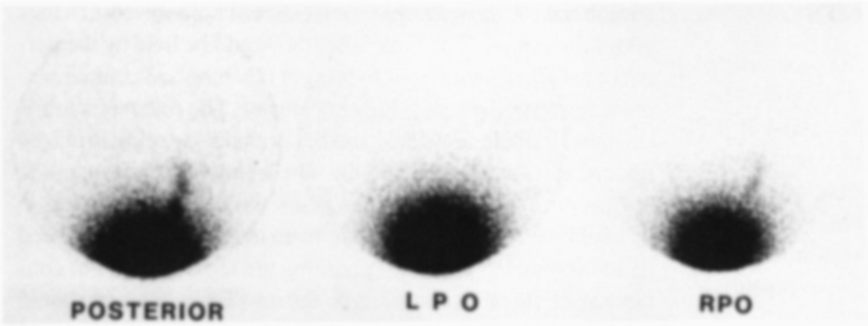

FIG. 1. Minimal transient reflux seen on posterior image, disappears on subsequent left posterior oblique (LPO) position and reappears on next right posterior oblique (RPO) image in sequence.

procedure is poorly performed by improperly trained or inexperienced personnel. It is our conviction that individuals such as technologists or parents, who regularly perform catheterization, become more efficient and less traumatic with their technique. Some individuals seem to be more gifted in interacting with the patient and parent and often this interaction is the most important aspect of achieving relaxation, which enables a rapid and safe catheterization. It is strongly recommended that in addition to studying this article, if one wishes to inaugerate RNC in their department, that both the physician and the technologist observe the technique several times in a department where the procedure is routinely performed. The technique then should be practiced under the direct supervision of an experienced individual.

TECHNOLOGIST'S ROLE

The technique of direct radionuclide cystography requires meticulous attention by the technologist to multiple details in order to derive an adquate study with clinically useful information. These technical functions include interaction with the parents and patient, catheterization of the patient, observation of the patient during the examination, operating the imaging equipment, and constant observation of the persistence oscilloscope. Since the performance of cystography requires complete distention of the bladder, which is associated with a serious urge to void, the technologist must be sensitive to the patient's complaints but also exhibit a calm, yet authoritative, manner to control the situation. The procedure should be accomplished as quickly as possible with a minimum of trauma for patient comfort. With difficult and uncooperative patients, two technologists may be necessary to perform the study.

Vesicoureteral reflux is a dynamic process. It may appear only fleetingly and in minimal amounts (Fig. 1). The technologist must therefore constantly monitor the patient and the persistence oscilloscope in order to initiate imaging to document the reflux. If the technologist fails to recognize VUR on the persistence oscilloscope, a false-negative study may be the result. If a computer or multiformat imaging recorder is available, continuous imaging may document minimal or transient episodes of VUR more effectively.

Depending upon institutional and departmental policy, the nuclear medicine technologist's role may include performing the catheterization procedure itself, but only after proper training to avoid physical injury or psychological trauma to the child. After appropriate instruction and demonstration, the technologist should perform the catheterization procedure several times under the direct supervision of the responsible physician. Every attempt must be made to avoid a traumatic experience for the patient. A child who has a bad experience will not likely cooperate for subsequent examinations. Occasionally the child is treated by intermittent catheterization performed by the parent. It is preferable in this situation to allow the parent to perform the catheterization since the child will more readily accept the procedure. The catheterization procedure should be explained to the child and the parent in appropriate layman's terminology.

Some children, because of their young age or other experiences, will refuse to cooperate or indeed even listen to an explanation of the procedure. Under these circumstances, the technologist must explain to the parent the remaining available options, i.e., forceful immobilization or sedation, and make a judgment whether to proceed with the procedure or to avoid traumatizing the child even further. Occasionally, better cooperation is achieved if the parent leaves the room. In these instances, the nuclear medicine physician should be alerted to the problem.

Once the catheterization procedure is performed and the radionuclide is instilled into the bladder, the technologist must monitor the patient, the flow of saline into the bladder, and the persistence oscilloscope, as well as maintain firm control of the situation. The technologist's judgment is extremely important in achieving maximum bladder filling. The records of previous studies should be examined to determine the previously achieved bladder volume and every attempt should be made to exceed that volume. The volume may also be estimated by using a pediatric bladder volume formula (*16*). Adequate bladder filling is frequently difficult to assess, as some children learn that increased protestation may serve to hasten or abort the procedure. There are indicators that enable the technologist to recognize when complete filling of the bladder has been achieved, such as backup of flow in the infusion tubing or leakage of urine around the catheter. However, if these indicators are not present, when to stop filling remains a matter of judgment on the part of the technologist.

Leakage of urine is to be discouraged, as it invalidates the quantitative information. Only by gaining experience in the performance of radionuclide cystography will the technologist learn to make adequate judgments.

PARENT-CHILD INTERACTION

It is important to recognize the role the parent plays during the performance of a diagnostic procedure on the child. The psychology of parent–child interaction can either assist or be detrimental to the successful performance of the procedure. Frequently the parent may be more apprehensive about the procedure than the child and in verbal or nonverbal ways communicate the apprehension to the child. Observation of the parent–child interaction can alert the technologist to potential problems. It is helpful to review the patient's medical or nuclear medicine record to be alert to potential problems. The technologist must gain the confidence of both by interacting in a friendly manner, answering questions, and explaining the procedure in readily understandable terms for each. The technologist must deal directly with the child. This is usually done before bringing the child to the imaging room. The technologist introduces him- or herself, provides a brief explanation of RNC including the length of time necessary for the procedure, and reassures the child that the parent may stay in the room during the examination as long as the child cooperates. A good departmental rule is to allow the parent in the imaging room as long as the child is cooperative. At this time, the child is prepared by the administration of potassium perchlorate and having the child void.

CATHETERIZATION PROCEDURE

The patient is placed on the imaging table in a supine position with the camera beneath the table. The technologist should bring to the room all the necessary materials to perform the catheterization quickly. These include a catheterization tray, catheters of each available size, and the dose of ^{99m}Tc-pertechnetate. The size of catheter used depends upon the age and sex of the child. In females, a soft size 8 french Foley catheter is used in newborns and up to 1 yr of age, a size 10 french Foley catheter is recommended between ages 1 and 3 yr, and a 12 french Foley catheter may be used after 3 yr of age. Generally, a catheter one size smaller is used in boys for each age group. Importantly, the smaller the catheter used, the longer it takes to fill the bladder. Also, patients tend to void around nonballoon catheters prior to complete filling. Stiff feeding tubes are more hazardous and perforation of the urethra or bladder may occur.

The patient is encouraged to relax as the technologist explains the preparations and uses of each of the materials. The materials in the tray are opened and prepared for easy and quick access to expedite the procedure once the catheterization is started. The saline syringe to fill the Foley ballon is separated from its needle. Number 5 and 8 Foley balloons require 3 cm^3 of saline, whereas number 12 Foley catheters can accept 5 cm^3 of saline. The plastic protector cover on the needle for the ^{99m}Tc-pertechnetate syringe is loosened. The outer package cover of the Foley catheter is opened.

Female patients are positioned in the frog hip position, i.e., the soles of the feet are placed together while the legs are abducted with the knees flexed. After donning sterile gloves, the perineum is draped with the sterile papers in the catheterization tray. Another technologist should hold the child's legs under the drapes. The child's hands should be held by the parent or another technologist to prevent reaching and contaminating the prepared perineal area or catheter. The catheter is lubricated to facilitate insertion, and the drainage opening is placed into the sterile collection bottle. The technologist cleanses the periurethral area or the glans penis with antispetic solution by swabbing from top to bottom, from inside to out. The gloved hand holding the penis or spreading the labia should not contact any of the other materials on the tray. Every attempt should be made to maintain the sterility of the gloved hand.

It is essential to visually identify the urethral orifice in females. To achieve this, the index and middle fingers of the hand are flexed and fashioned as hooks to separate the labia and clear the area around the urethral opening (Fig. 2). The technologist explains that the insertion of the tube will cause a sensation mimicking the urge to void but will not hurt. Often deep breathing will help the patient to relax while the catheter is inserted. Since the urethral opening is immediately anterior to the vaginal orifice and the urethra is projected posteriorly, the catheter is easily inserted by aiming the tip posteriorly and by using a gentle downward gliding motion while pressing the tip of the catheter to the perineum. As the catheter enters the urethral opening, it should be further inserted past the balloon portion quickly in one motion. A mild resistance is normally encountered as the balloon portion enters the external sphincter. Resistance to insertion is an indication of a problem such as a urethral stenosis. A smaller size catheter should be tried. On occasion, the catheter may slide into the vagina, but it is usually quite obvious since the catheter either does not advance very far or may fold on itself, so that the tip is seen exiting from the vagina.

If the catheter is placed correctly, there often will be urine return even if the patient voids completely prior to the procedure. Rarely, one may not retrieve any urine from the emptied bladder. If there still is doubt regarding the placement of the catheter, then saline should be infused through the catheter since prompt leakage from the vagina will occur. The Foley balloon is distended slowly to prevent injury in case of urethral or ureteral location of the balloon. Any expression of pain by the patient during filling of the balloon demands an immediate deflation of the balloon and reassessment of the position of the catheter.

Upon successful catheterization, a sample of urine is collected in a sterile bottle for culture and urinalysis. The postcatheterization residual volume is collected, measured, and recorded. The catheter drainage opening is then connected to a bottle of body temperature normal saline via intravenous administration tubing. After free flow of saline is established, 1 mCi of ^{99m}Tc-pertechnetate is injected via the rubber injection port on the administration tubing.

In males, the urethra is anesthetized by administration of an anesthetic jelly. One can carefully inject the jelly into the urethra with a syringe or more commonly, the catheter is simply lubricated with the anesthetic jelly. The catheter is then introduced into the bladder while the patient breathes deeply or attempts to void to relax the internal sphincter. A continuous

FIG. 2. Sterile Foley catheter insertion into urethra. Note use of fingers as "hooks" to spread labia.

gentle pressure of the catheter tip on the internal sphincter until it relaxes will cause the catheter to slide through the sphincter. If any difficulty is encountered during the catheterization procedure, it may be necessary to use a smaller nonballoon catheter. However, the referring clinician in charge should be alerted to the problem and requested to insert the tube. A nonballoon catheter should be taped to the upper thigh with nonallergenic tape.

IMAGING TECHNIQUE

The supine patient is positioned so that the upper third of the bladder is visualized at the bottom of the field of view. Usually, the upper urinary tract will also be included in the image depending upon the field of view of the camera and the size of the child. The persistence oscilloscope is continuously monitored during bladder filling so that imaging can begin immediately when VUR is visualized. If VUR is not seen, imaging is begun when the bladder reaches maximum capacity.

The assessment of sufficient bladder filling may be difficult. Some children begin protesting almost immediately since the presence of the catheter stimulates the urge to void, and as the bladder fills, the protestations may also increase. An awareness of the level of protest as an indicator of imminent voiding is only gained by experience. Other indicators of sufficient bladder filling include cessation of flow or backup of saline in the infusion bottle, leakage around the catheter, curling toes or crossing of the legs (*17*). Finally, a formula to estimate the bladder capacity based upon the patient's age has been developed. A normal bladder capacity should approximate in milliliters the (age + 2) × 30 (*16*). Bladder capacities appear to vary from the formula after 9 yr of age. The formula is used only as a rule of thumb since capacities can also vary depending upon the health of the bladder. For example, smaller capacities are seen in patients after a surgical procedure on the bladder or after recurrent infections. Again, determination of adequate bladder filling is ultimately dependent upon the technologist's judgment.

The technologist must work quickly to demonstrate VUR on permanent images. Posterior and both posterior oblique images are obtained with a high intensity setting that demonstrates background activity throughout the field of view. This is necessary in order to adequately demonstrate minimal amounts of reflux. If imaging is attempted with the majority of the bladder in the field of view, VUR may be missed since most of the photons will be derived from the bladder. Images are recorded for a total of 300,000 counts. Occasionally, fleeting minimal VUR into the distal ureter may occur, which is not demonstrated on permanent images. This should be noted for the correct interpretation of the study. The technologist also must note any unusual occurrences or problems on the data worksheet (Fig. 3), as well as record the total volume of saline instilled and the volume of saline that was infused at the time of VUR for both the left and the right kidneys.

A 2-min posterior image including the entire bladder and the upper urinary tracts is then obtained and identified as the prevoid image. The total counts for the 2-min image are recorded on the worksheet to be used in calculating the residual volume. This image is acquired at a lower intensity setting in order to more adequately evaluate the bladder. On occasion, minimal VUR into the distal ureter which has been obscured by the higher intensity settings is visualized.

RADIONUCLIDE CYSTOGRAM

NAME:	______________________
HOSPITAL NUMBER:	______________________
DATE:	______________________
DOSE:	______________________
Right Reflux at	________________ cc
Left Reflux at	________________ cc
Total Instilled	________________ cc
Urinary Bladder:	______ Pre-Void ______ Post-Void
Voided Volume of Urine:	________________ ml.
Residual volume =	voided volume × residual count / initial count − residual count
Residual volume =	______ × ______ = ______
Reflux Bladder Volume	
Total Volume =	voided volume + residual volume
Total Volume =	______ + ______ = ______
Production − Initial Volume =	Total − Total Instilled
Production − Initial Volume =	______ − ______ = ______
Reflux Volume =	Production − Initial + Bottle Volume
Reflux Volume =	R ______ + ______ = ______
Reflux Volume =	L ______ + ______ = ______

FIG. 3. Data worksheet.

The voiding image is performed with the patient seated to void into a bedpan or a urinal and by positioning the camera against the patient's back. The catheter is removed by deflating the balloon and the patient is encouraged to void. Deflating the balloon must be done slowly and carefully since, rarely, the balloon can fold back or crinkle on itself creating a ridge that makes removal of the catheter difficult or painful. If the catheter does not slide out easily, no attempt should be made to pull on it or remove it with force. The volume of saline removed from the balloon should be the same as that which was instilled. If the catheter fails to move easily, the balloon should be reinflated with saline and then deflated again by slow removal of the saline without force on the plunger of the syringe. If a problem is still encountered, the clinician in charge should be alerted before any further attempts at removal.

The voiding image is acquired with the same high intensity setting as the prevoid images. Reflux that occurs only during voiding due to an increased bladder pressure will thus be documented (Fig. 4). If desired, the voiding sequence may also be recorded with a computer. The reflux drainage time can be determined by generating a time activity curve using regions of interest over the refluxed radioactivity in the kidney (*3,10,17*). The reflux drainage time may be of prognostic significance (*18*).

The voided urine is collected and the volume is recorded on the worksheet for the calculation of residual urine volume. Finally, a 2-min postvoid image including the bladder and the upper tracts is obtained at a high intensity setting. The counts obtained during the various imaging intervals are necessary for the calculation of residual urine volume. If desired, the actual refluxed volume of urine can be determined by, again, placing areas of interest over the kidneys. When the residual volume has been calculated, the ratio of the kidney activity to the total abdominal activity will allow calculation of the actual volume of urine that has refluxed. Occasionally, children will not void on request. This problem can be overcome by having the child void in privacy in the bathroom. If the voided volume of urine is lost, the calculation of residual volume cannot be performed. The residual volume may be estimated subjectively by the appearance of the postvoid image.

The calculation of the reflux bladder volume and the volume of reflux into the kidney is achieved by first determining the residual urine volume remaining in the urinary tracts after voiding. The residual volume is calculated by the formula:

$$\text{Residual volume} = \frac{(\text{Voided volume} \times \text{Residual count})}{(\text{Initial count} - \text{Residual count})}$$

Next, the total volume at maximum capacity can be calculated by the formula:

$$\text{Total volume} = \text{Voided volume} + \text{Residual volume}$$

One must be aware that there usually is a volume of urine produced during the examination or remaining after the initial catheter drainage of the bladder that is included in the total

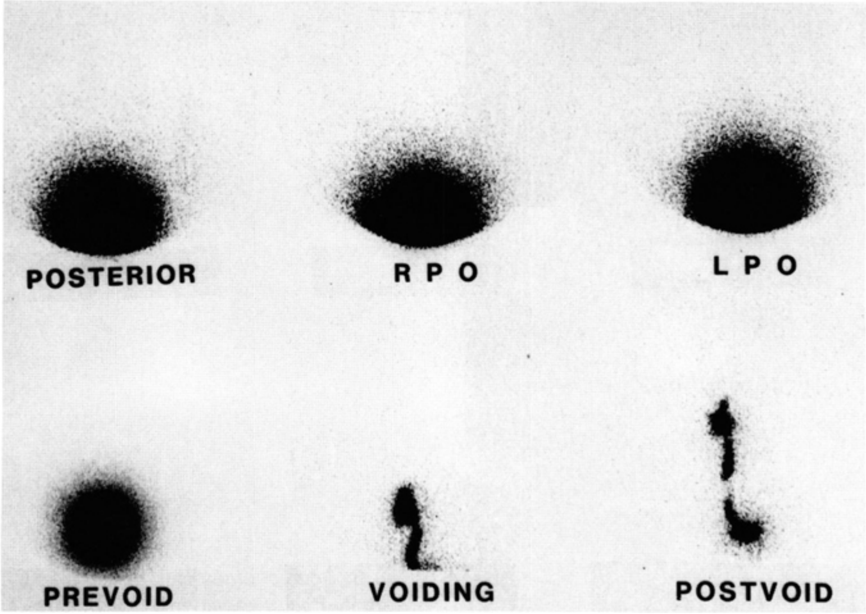

FIG. 4. Reflux into upper urinary tract is seen only with child upright on voiding film. Residual activity remains on postvoid image. RPO, right posterior oblique; LPO, left posterior oblique.

volume. This volume of urine is termed the production–initial volume. To determine the production–initial volume the following formula is used:

$$\text{Production-initial volume} = \text{Total volume} - \text{Total saline instilled}$$

The reflux bladder volume for each kidney is determined by the formula:

$$\text{Reflux bladder volume} = \text{Initial volume} + \text{Saline reflux volume}$$

If desired, the volume of urine refluxed into the kidney can be determined by the formula:

$$\text{Kidney reflux volume} = \text{Kidney counts} \times \frac{(\text{Total volume})}{(\text{Total counts})}$$

Remember, none of these calculations is accurate if any urine is lost during the procedure. The technologist should note on the worksheet any loss of urine for the clinician's use in interpreting the study.

There is a 10% attenuation of photons per 100 ml of bladder volume. Thus, a residual volume of 18 ml is actually 20 ml. This small difference does not change the calculations sufficiently to affect the clinical interpretation of the results and therefore it can be ignored. Any residual volume, if it is in the bladder, may be spurious since the child may simply not have wanted to void. A completely emptied bladder on the postvoid image is of clinical interest.

RADIONUCLIDE CYSTOMETROGRAM

Dysfunctional bladder abnormalities may be recognized by the simultaneous recording of bladder pressures during direct radionuclide cystography. This has been termed the radionuclide cystometrogram (*13*). Intravesical pressure is measured through the drainage port of the Foley catheter by a physiological pressure transducer* and by recording the cystometrogram on a single channel amplifier recorder†. A 22 gauge intracath needle is used to create an additional port in the drainage lumen of the catheter for instillation of the saline at about 3 cm from the urethral meatus (Fig. 5). The graphic pressure representations are calibrated prior to each study to display the pressure measurements in centimeters of water. Of importance, the technologist must note directly on the strip chart recording the point at which the patient expresses the first sensation of fullness, the first sensation of urgency, and other patient reactions or movements, as well as the saline volumes and the occurrence of reflux. These subjective interpretations of the patient's responses are dependent upon the technologist's judgment. Having the patient purposefully cough at the start of and occasionally during the procedure will insure that the pressure changes in the bladder are being transmitted through the system onto the graphic recording. The cystometrogram recording is discontinued prior to the voiding image.

Four pressure patterns have been characterized: 1) normal, 2) spastic-reflex, 3) flaccid-paralytic, and 4) uninhibited bladder contraction (*19*). The spastic-reflex or flaccid-paralytic patterns may be observed in patients with neurologic bladder disorders. The uninhibited bladder contraction pattern is often found in children with a voiding dysfunction. Occasionally, the radionuclide cystometrogram recording is of limited value because of poor patient cooperation, as any patient motion or crying will create pressure artifacts on the recording.

TECHNICAL PITFALLS

There are a few technical difficulties associated with the performance of direct radionuclide cystography. Most problems relate to the ability of the child to cooperate during the examination. There are few artifacts that can simulate reflux. If radioactive urine contamination occurs from leakage around

FIG. 5. Double lumen catheter created by insertion of an intracath into Foley catheter. Saline is infused via intracath while pressure is monitored through Foley outlet. Technetium-99m is administered via intravenous infusion tubing port.

the catheter, it usually is not confused with reflux because it has a characteristic bizarre location at the periphery and around the buttocks of the patient (Fig. 6). Vesicoureteral reflux is seen only directly above the bladder. Equipment contamination from urine leakage can be controlled by placement of plastic-lined absorbent paper or a disposable diaper beneath the patient. If leakage occurs, the absorbent paper should be replaced before imaging is resumed and, if necessary, the patient should be washed to remove any skin contamination. Contamination of the scintillation camera or imaging table is rarely a problem when the absorbent paper is used. Devices such as restraining boards are not used since leakage of the urine contaminates the board and the wrappings; these must be cleaned before imaging can proceed, thus significantly delaying the procedure. Contamination of hip spica casts produces persistent artifacts. Infants or retarded children can be particularly uncooperative; however, the use of sedation or restraining devices is not advocated, as sedation has a possible effect upon the physiology of VUR and the restraining devices enhance the chance for contamination. Leakage of urine is a major problem in newborn and meningomyelocele patients. Leakage of urine occurs at low bladder volumes, and therefore, frequently, the entire sequence of images cannot be obtained in these patients.

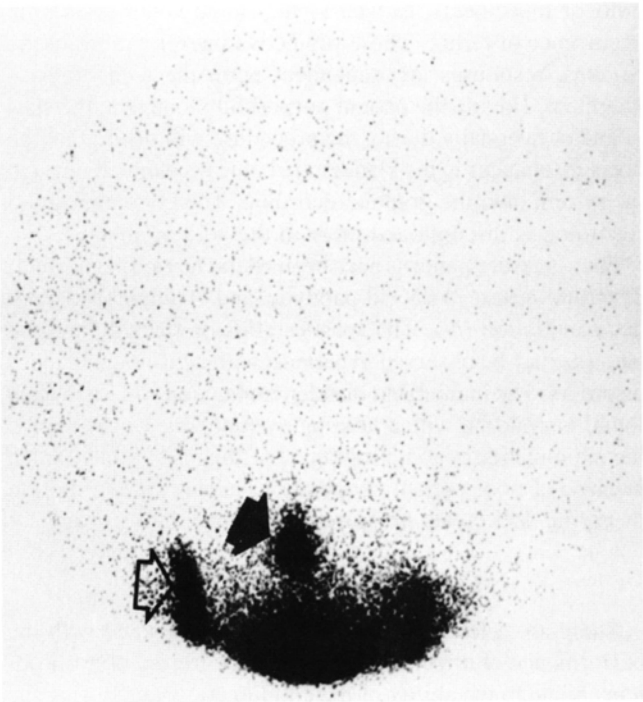

FIG. 6. Characteristic appearance of urine leakage around buttocks (open arrow) is not easily confused with refluxed activity (solid arrow).

Rarely, the catheter may be inadvertently inserted into the vagina instead of the bladder. This usually is easily recognized since there is almost immediate leakage of the saline around the catheter. If the ^{99m}Tc-pertechnetate is instilled it will become obvious that the catheter is not in the bladder because of the elongated shape of the vagina. The fallopian tubes may even be visualized. This is not easily confused with reflux into the ureters.

There are additional technical difficulties that may be encountered when performing the cystometrogram. The apparatus must be carefully calibrated to reflect the pressure in centimeters of water. To calibrate the system, a pressure manometer from a lumbar puncture tray is connected to the chart recorder

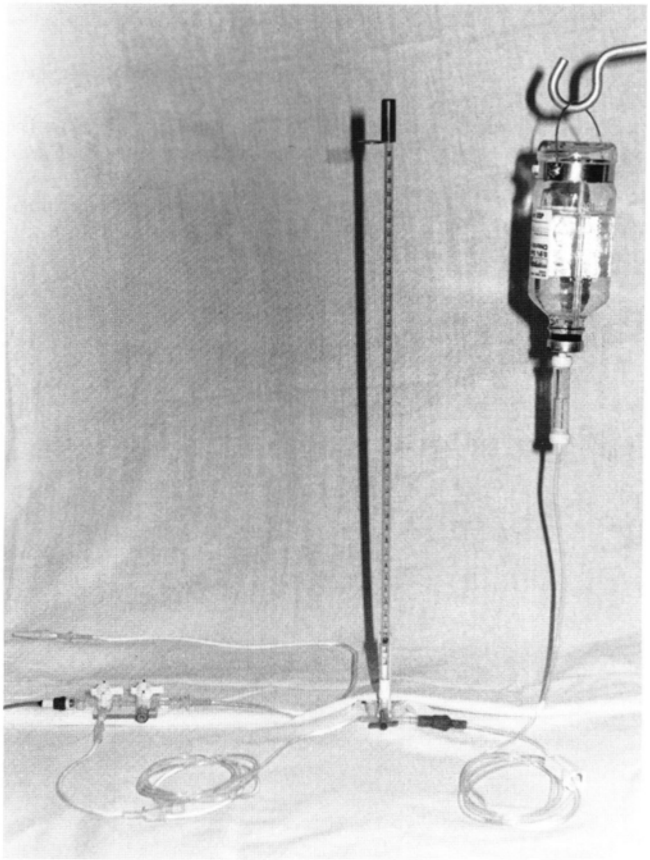

FIG. 7. Cystometric calibration system. Transducer connected via 2 gang stopcock to manometer which measures up to 40 cm of water.

via the pressure transducer through one outlet of a 2 gang 4-way stopcock, and on the other outlet of the manometer, a bottle of saline (Fig. 7). The manometer is zeroed at the same height as the table upon which the patient will be positioned, which is approximately the same level as the bladder. The system is then calibrated to reflect pressures from 0–80 cm of water full scale. Prior to each study the calibration is checked, measurements are recorded at 10, 20, 30, and 40 cm of water, and the sensitivity of the recorder is adjusted appropriately to correct for drift of the pen. There must be a continuous column of water in the entire system in order to accurately reflect pressure. Any air bubbles will produce pressure artifacts and therefore they must carefully be eliminated by flushing the system. Once the system is connected to the catheter for use in an actual procedure, any movement of the tubing or the transducer will produce erratic changes in the pressure recording. Erratic changes in the recording are also produced by movement, crying, or attempts to void by the patient. The technologist must indicate all such occurrences on the recording graph so that the physician does not confuse such artifacts with uninhibited bladder contractions.

The opening "empty" bladder pressures at the beginning of the procedure should not exceed 10 cm of water pressure. If the opening pressure is greater than 10 cm then the technologist must search for a cause, which may include inappropriate placement of the transducer, inappropriate placement of the catheter, or other unusual causes. The performance of a radionuclide cystometrogram places a greater burden and responsibility on the technologist since one must observe the patient, the persistence oscilloscope, the flow of saline in the IV tubing, and the bottle, as well as the pressure transducer recording, while simultaneously recording the data on the graph or worksheet. The interaction with the patient and the parent is extremely important since anything the technologist can do to create a calm atmosphere will enhance the study and eliminate artifacts. A technique that has been used successfully is to demonstrate to the patient the effect that coughing or crying has on the pressure recording.

In summary, direct radionuclide cystography is an important diagnostic tool in the diagnosis and follow-up of children with vesicoureteral reflux. The technique is relatively simple, yet it is heavily dependent upon the technologist's training and judgment. One should not attempt to perform direct radionuclide cystography or the radionuclide cystometrogram without being completely familiar and confident with the technique. The technologist who is not well trained may easily produce an inaccurate study, miss deriving valuable quantitative data, or cause physical or psychological trauma to the child. The technologist's role in the performance of radionuclide cystography requires meticulous attention to detail and expertise in the performance of catherization, as well as a good understanding of the parent–child interaction. The technologist must be able to recognize technical pitfalls in order to prevent misinterpretation by the physician.

NOTES

*Model PSO, Gould, Chicago, IL.
†Model 2200, Gould, Chicago, IL.

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