What is the normal urinary tract?

The kidneys filter the blood and extract waste products from the blood to make urine. Urine passes from the kidneys, down the ureters, and into the bladder for storage prior to urination.

The ureter enters the bladder wall at an angle so that a flap valve is created. This valve prevents urine that is in the bladder from backing up and returning into the ureter and kidney. Thus, when the bladder fills and later when it squeezes down to empty, back-up (reflux) is prevented because the valve operates in the same way as you might step on a straw.

This valve-like action creates an important barrier that helps keep the kidneys free of bacteria. Once urine has passed from the upper urinary tract into the bladder, the normal valve not only makes certain that urine does not re-enter the upper tracts, but also that the high pressures created at the moment of urination are not transmitted to the kidneys. Another important feature of the competent valve (ureterovesical junction) is that it permits you to remove all of the stored urine from the body with a single act of urination - because the bladder urine has nowhere to go other than out the urethra.

What is Vesicoureteral Reflux?

The valve system at the ureterovesical junction may be abnormal for a few reasons. In many patients the tunnel of the lower ureter through the muscular wall of the bladder may not be long enough. A ratio of at least 4:1 of tunnel length to ureteral diameter is necessary to assure competence of the valve (this means that the part of the ureter traveling through the wall of the bladder should be at least four times as long as it is wide.) For some children, there is a
good chance that growth may provide the necessary difference to allow the valve to work.

Another reason for reflux may be that the location of entry into bladder is abnormal (usually too much to the side.) The result of this bad location is a short tunnel. Resolution of reflux with growth is less likely when the ureteral opening is in a very abnormal location (ectopia).

Some children have reflux because of underlying problems such as lower urinary obstruction (such as urethral valves), abnormal bladder behavior, infrequent voiding, or constipation.

What are the problems with reflux?
The main problem with reflux is that it exposes the kidneys to infection. In children, particularly those in the first six years of life, urinary infection can cause kidney damage. Injury to the kidney may result in a small area of scarring, loss of future growth potential, or widespread scarring and atrophy. Even a small area of scarring in one kidney may be a cause of high blood pressure later in life.

Untreated reflux results in incomplete emptying of the urinary tract, infection may be encouraged. Some patients are also susceptible to kidney stone formation because of their reflux.

How is reflux evaluated?
Our baseline evaluation of vesicoureteral reflux consists of an upper tract study and a lower tract study. For most children, upper tracts can be adequately evaluated by ultrasound. Even though we call this "the upper tract study" at Mott Children's Hospital it also includes a careful look at ureters and bladder. The quality of ultrasound at Mott has become so consistently high that
intravenous pyelograms (IVP - involving intravenous injection and conventional x-rays) are no longer routinely necessary. When, however, some aspect of the ultrasound study is suspicious or when the clinical history suggests further evaluation, we will go ahead and recommend an IVP.

Reflux is evaluated by a voiding cystogram and this generally requires a catheter passed into the bladder to fill it with an imaging substance. The catheters used are very small (usually the same size used for newborn babies.) Nonetheless, for a "first-timer" this procedure is threatening and requires some preparation and reassurance. We give the patient a short course of antibiotics to cover this procedure if none are otherwise being taken. A contrast voiding cystourethrogram (VCUG), will also image the entire urethra to rule out valves or other problems. Minimal x-ray exposure is involved and the testicles are protected in boys. A nuclear voiding cystogram does not offer urethral visualization, but involves almost negligible radiation. The bladder is instilled with a tiny amount of radioactive material and the ureters and kidneys are scanned with a special camera during filling and voiding. The radioactive substance has a very short life and is passed directly out of the urinary tract without absorption into the body. This test is more sensitive than the x-ray VCUG although not quite as specific in showing the degree of reflux. Reflux is classified into five grades - grade I is the least and grade V is the most severe.

**What are the options for nonoperative management of reflux?**

When reflux is related to an underlying problem such as constipation, infrequent voiding, abnormal bladder activity, or blockages such as strictures or valves, the predisposing factor should be corrected and the reflux then re-evaluated. The majority of reflux in children is related to bladder overactivity which may resolve with time, medicines, treatment of infection, voiding training, or biofeedback.
Mild degrees of reflux have a good chance of being outgrown (resolution of reflux) with age. In 4 out of 5 children with mild to moderate degrees of reflux, resolution can be expected over the course of some years. Unfortunately, there is no magic crystal ball that will tell us exactly when the reflux will go away for a particular child - although recent data suggest that resolution should be expected within a few years. The chance of resolution of high grade reflux related to an anatomic problem is much lower.

Most of our refluxing children are given a chance to outgrow their reflux. It is essential that they be protected from urinary infection during this time, and for this we use low doses of prophylactic antibiotics. After a 1-2 year interval with antibiotics, reflux is re-evaluated. At the same time we check the kidneys with ultrasound to be certain they are growing properly.

No antibiotic is risk-free and no antibiotic will destroy all bacteria. Nonetheless, Bactrim or Septra (same drug, different companies) have proved the most effective prophylactic agents with minimal side effects and these are usually our first choice.

During the course of nonoperative management, any fever or urinary tract symptoms (burning, frequency, urgency, straining, foul odor, bloody urine, or unusual incontinence) must be aggressively evaluated with urine analysis and urine culture. A breakthrough urinary infection, in spite of prophylaxis, is a dangerous situation indicating that we are unable to protect the kidneys with a nonoperative course of management and that the next step would be surgical correction of reflux.

How is reflux corrected surgically?
Correction of reflux (ureteral reimplantation =ureteroneocystostomy) is recommended for high grades of reflux, for reflux that fails to resolve, as for
patients with breakthrough infections. The traditional surgical approaches have high degrees of success and usually involve opening the bladder and creating a new longer tunnel for the ureter to pass through the bladder wall. If the ureter is very wide it may need to be narrowed to make a successful flap valve with at least a 4:1 ratio of tunnel length to ureter width. In many instances surgical correction can be done without opening the bladder (detrusorraphy) by using bladder muscle to create a valve where the ureter enters the bladder.

Complications include bleeding and infection in the short run, urinary leakage and bladder spasms in the intermediate time course, and obstruction or persistent reflux later. The child is left on prophylactic antibiotics for several months until postoperative studies prove that the reflux has been corrected. Success rates with these methods are 98-99%.

**What is intravesical correction of reflux?**

Reflux can also be corrected by injecting material directly into the bladder through a cystoscope. This potentially will spare the patient a traditional operation with incision and can be done on an outpatient basis. The materials currently in use are Deflux, Teflon, and collagen. This approach to reflux correction is still somewhat controversial. Teflon persists lifelong and may migrate to other sites in the body, although it seems to be inert and harmless. This is not approved by the FDA. Collagen, a biodegradable material, does not have nearly as high a success rate as open surgery, and therefore has limited value in our patient population. These substances led to the development of a new material Deflux. This is material made from a type of sugar molecule which is stabilized by cartilage molecules. Deflux has been approved by the FDA and appears to be stable. Studies suggest that some patients take 2 to 3 injections and about 78-85% achieve full cessation of the reflux.

**What is the follow-up process for refluxing/reimplanted patients?**

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We think that all patients with a history of reflux should be monitored life-long. This usually involves little more than periodic visits after reflux has been outgrown with measurement of height and weight, blood pressure and urine analysis. Kidney function can be crudely evaluated by blood tests (creatinine and BUN) or more precisely checked by creatinine clearance or glomerular filtration rate. Occasional ultrasound tests will assure that kidney growth is on target for size and age. The corrected refluxer is similarly followed after the initial postoperative studies.

By the time surgical correction has been performed, some children have already had significant kidney damage. This is apparent in the finding that close to 20% of patients who had undergone surgical correction of reflux later developed high blood pressure. In other patients, the kidney damage from reflux earlier in life may result in kidneys that don't grow in size or function proportionately with the body and thereby seem to deteriorate with age. When kidney deterioration has been demonstrated the Pediatric Nephrology Team must begin careful surveillance with appropriate medication and dietary restriction.

**What are the chances of a sibling having reflux?**

If a child with reflux has a brother or sister there is a 1 in 3 chance that the sibling will also have reflux which may already have caused kidney damage in the absence of any clinical suggestion of urinary infections. Because we know that the chances of kidney damage are highest in the first 6 years of life, we may suggest that the siblings be screened with an ultrasound and possibly VCU.