Practical urodynamics

Perfusion pressure flow study in the upper urinary tract

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1. Introduction

Hydronephrosis with an undetermined pathology is not an uncommon condition detected in urological imaging examinations. It accounts for 1–2% of pregnancies in prenatal ultrasonography and is more frequently observed in the general population during routine ultrasound screening. Hydronephrosis is defined as the dilation of the renal pelvis observed in imaging. For a long time, hydronephrosis has been recognized as not being synonymous with obstruction, and it does not necessarily result in the deterioration of renal function. Long-term obstruction of the collecting system will limit renal growth in children and lead to the deterioration of renal function in well-developed kidneys. Currently, imaging studies used for detecting hydronephrosis include ultrasound, intravenous urography, computed tomography, and magnetic resonance imaging. Diuretic renography is also used for evaluating renal function. However, even when these techniques are used exhaustively, it remains difficult to predict whether hydronephrosis will lead to the deterioration of renal function damage and whether timely intervention can result in the recovery of renal function.

Direct pressure measurement of the renal pelvis is an alternative method to evaluate obstruction. It is derived from flow dynamics studies where obstruction implies increased resistance to flow and results in increased pressure force to compensate for peristalsis and finally damage of renal function. Perfusion provocation study was introduced by Bäcklund et al. in 1965. Whitaker performed the dynamic assessment of the upper urinary tract and popularized the perfusion pressure flow study, which could be used to detect obstruction.

The test is referred to as the comparative standard study and has been widely used in the diagnosis of urinary tract obstruction. In this paper, we present the technique for perfusion pressure flow study, which is well known as the Whitaker test.

2. Equipment and setting

Percutaneous nephrostomy (PCN) tube (8Fr.), Perfusion pump or syringe pump, Pressure transducers, and One bottle of normal saline with or without contrast media (Telebrix 35 iodine: 350 mg/ml, 100 ml/vial).

3. Perfusion pressure-flow study

The patient underwent PCN tube insertion, performed by a radiologist, 2–3 days before the perfusion pressure flow study was conducted (Figs. 1–3). During the study the patient was placed in a supine position, fully awake for adults and cooperative patients, or under general anesthesia, just prior to the surgery. A 6F dual lumen catheter was indwelled in the bladder for measuring

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bladder pressure. The PCN tube was connected to a perfusion pump and a tube for detecting the pressure via a three-way switch. The perfusion pumping rate was maintained at 10 mL/min of normal saline with or without the contrast medium (Tel-ebrix 35 Iodine: 350 mg/ml, 100 ml/vial).

4. Indications

Indications included suspicion or evidence of obstruction in the upper urinary tract.

5. Criteria

The following criteria were followed:

1. Obstruction: the pressure gradient between the renal pelvis and the bladder is $\geq 22$ cmH$_2$O.
2. Equivocal: the pressure gradient between the renal pelvis and the bladder ranges from 15 to 22 cmH$_2$O.
3. Nonobstruction: the pressure gradient between the renal pelvis and the bladder is $< 15$ cmH$_2$O.

6. Discussion

Currently, the choice of diagnostic method used for obstruction in the upper urinary tract is diuretic renography with well-tempered renography which offers relative renal function and time-activity curve patterns to categorize whether an obstruction is present. It is well known that diuretic renography is more convenient than a perfusion pressure flow study in an adult with well-matured kidney function, and at present it is the standard procedure used. However, it is too complex for children with growing kidneys, administration of intravenous isotope, and fluid infusion, and in some cases requires repeat procedures.

Since the introduction of the Whitaker test in the 1970s, its use for the diagnosis of upper urinary tract obstruction in the upper urinary tract has been controversial. Proponents agree that pressure gradients between the renal pelvis and the bladder can be used to distinguish obstructions from nonobstructive dilatation, and the setting of an obstructive relative renal pressure increase at 22 cmH$_2$O is compatible with urinary tract pressures at which renal damage is believed to occur. In 34 children, Dacher et al demonstrated that the pressure flow study can be considered in equivocal cases of diethylene-triaminepenta-acetic acid furosemide diuresis renography. Throughout Lupton and George’s 25-year experience, 145 studies were assessed. The Whitaker test determined or contributed to the clinical management in 84% of the cases studied, and it accurately predicted the outcomes in 77% of
obstructed cases and in 77% of nonobstructive cases.10 During a long-term follow up, Veeboer and de Jong11 noted that, although it is not often used anymore, perfusion pressure flow study seems to be a useful diagnostic tool in the workup of possible upper urinary tract obstruction in children, especially in cases where conservative watchful waiting is of concern.

Meanwhile, the Whitaker test was criticized for its invasiveness, nonphysiological approach, and inconsistency in clinical outcomes. Djurhuus et al12 investigated 31 patients undergoing surgery for hydronephrosis and found no consistent differences in pressure between obstructed and unobstructed renal pelvises, and recommended that pressures were of no value in predicting the outcome of surgery for hydronephrosis. Koff13 also showed normal pressure gradients in some kidneys with obstructed ureters.

The pressure gradients that are regarded as indicating obstructive, equivocal, or nonobstructive states were initially set arbitrarily. Later, these gradients were modified on the basis of experimental and clinical studies.3 More recently, a modification of the Whitaker method was developed in which the pressure level, rather than the infusion rate, is kept constant and the resistance index is calculated to quantify the level of obstruction.14,15

7. Conclusion
The perfusion pressure flow study continues to have a role in modern urological surgery. It should be reserved for assessing potential cases of upper urinary tract obstruction.

Conflicts of interest
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References

Editorial comment
Differentiation of obstructed from dilated, nonobstructed upper urinary tract to predict whether the renal function will deteriorate has been a puzzling issue. Perfusion Pressure flow study, known as Whitaker test and diethylenetriaminepenta-acetic acid (DTPA) diuretic radionuclide renography are the most common methods in clinical practice. Nevertheless, it remains controversial concerning which test is favorable for the confirmative diagnosis of obstructed upper urinary tract. The main advantage of Whitaker test is it does not depend on renal function. The relative advantage of DTPA diuretic radionuclide renography is non-invasiveness and lower cost. When both tests consistently agreed, the diagnosis of obstructed upper urinary tract is more likely to be accurate. Due to the noninvasive nature, DTPA diuretic radionuclide renography should be the initial procedure for the diagnosis of obstructed upper urinary tract in patients with hydronephrosis. If DTPA diuretic radionuclide renography shows indeterminate results or equivocal results, then the Whitaker test should be considered to further confirm the diagnosis.

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