IN UTERO *insights*

Volume 2
Issue 3
FALL
2011

The Children's Hospital *of* Philadelphia®

CENTER FOR FETAL DIAGNOSIS & TREATMENT

Dear Colleague,

From simple defects that cause severe problems, such as lower urinary tract obstructions, to complex conditions such as vesicoureteral reflux, prune belly variant, cystic kidney disease and disorders of sex development, congenital urologic anomalies may cause life-threatening symptoms and long-term challenges. In some cases, irreversible and severe morbidity or disability can develop and worsen *in utero*.

At the Center for Fetal Diagnosis and Treatment at The Children's Hospital of Philadelphia, prenatal diagnosis offers options to families, from *in utero* therapy to preserve renal function to delivery with urologic subspecialists immediately available to the newborn. Our multidisciplinary team sees patients with these rare conditions on a regular basis and provides comprehensive, family-centered care from before birth through long-term follow-up, sometimes well into adulthood.

The depth and breadth of every pediatric specialty throughout Children's Hospital enable us to address any conditions that arise throughout the continuum of care. And our Center's continued research into the pathogenesis of these conditions is paving the way to better treatment options.

This issue of *In Utero Insights* provides a detailed look at the resources we offer patients whose pregnancies present with rare congenital urologic anomalies, as well as anomalies whose urologic implications arise after birth, such as spina bifida.

We value the opportunity to partner with you in providing expert, complete care for these patients and, as always, we welcome your feedback.

Sincerely,

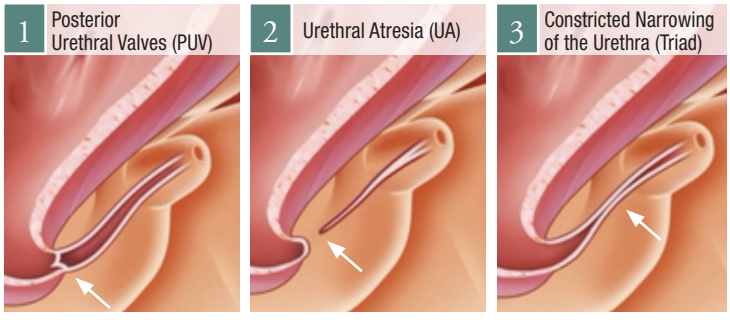
N. Scott Adzick, M.D., M.M.M.
Surgeon-in-Chief
Director, Center for Fetal Diagnosis and Treatment

Lori J. Howell, R.N., M.S.
Executive Director, Center for Fetal Diagnosis and Treatment

OBSTRUCTIVE UROPATHY: PATHWAY TO IMPROVED OUTCOMES

Lower urinary tract obstructions (LUTO) are simple anatomic defects that can have major consequences for a developing fetus. Proper diagnosis, treatment and follow-up require an experienced, multidisciplinary team that understands not only the pathogenesis of this condition but also the best options for treatment. At the Center for Fetal Diagnosis and Treatment at The Children's Hospital of Philadelphia, a team of high-risk obstetricians, pediatric surgeons, anesthesiologists, advanced practice and surgical nurses, radiologists, genetic specialists, neonatologists, urologists, and nephrologists sees an average of 25 prenatal cases of this rare, life-threatening disorder each year, offering an unparalleled level of expertise.

LUTO occurs as a result of either a partial or complete obstruction of the penile urethra that restricts or prevents the passage of urine to the amniotic fluid space around the fetus. Lower urinary tract obstructions come in a variety of forms, including posterior urethral valves (1), urethral atresia (2) and constricted narrowing in the mid-portion of the urethra, known as Triad syndrome (3). Long-standing obstruction causes back pressure on the kidneys, which impairs renal function, as well as oligohydramnios, which can result in underdeveloped lungs (pulmonary hypoplasia) and secondary deformations of the face and extremities, referred to as Potter sequence.



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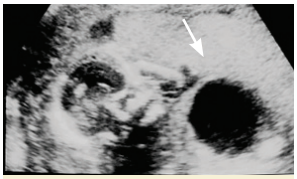
OBSTRUCTIVE UROPATHY: PATHWAY TO IMPROVED OUTCOMES

An initial diagnosis of LUTO is usually made by ultrasound between 18 and 24 weeks. Once referred to the Center, a one-day evaluation — including high-resolution level II ultrasound, fetal echocardiogram and ultrafast fetal MRI in complex cases — confirms the diagnosis and provides the family with options for care. Serial vesicocentesis is performed two to three times at 24 to 48 hour intervals to evaluate kidney function, a standard established in studies led by Mark P. Johnson, M.D., director of obstetric services for the Center for Fetal Diagnosis and Treatment.



Overfilled bladder due to

Male fetuses that have no other syndromic or chromosomal abnormalities and show serial improvement in urine electrolytes to below thresholds established by outcomes studies at the Center may be candidates for fetal intervention (female fetuses typically have a more complex cloacal anomaly that will not benefit from fetal intervention). Upon completion of all testing, a multidisciplinary team meets with families to review test results, discuss the diagnosis, explain treatment options and potential outcomes, and answer questions. Candidates for fetal intervention also meet with a urologist to discuss postnatal management and treatment options.

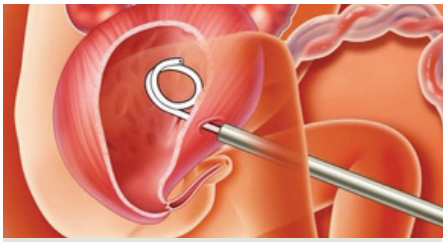
The rationale of fetal intervention via vesico-amniotic shunting is to provide an alternate passageway bypassing the obstruction and re-establishing normal amniotic fluid volume. Seamless teamwork is essential during shunt placement, an invasive procedure whose risks include premature rupture of membranes, chorioamniotic separation, intraplacental bleeding and direct trauma to the fetus. Shunting is performed as an outpatient procedure. The mother receives antibiotics, IV sedation and local anesthesia. Under ultrasonographic guidance and color-flow Doppler, a 3 mm trocar is guided through the maternal abdomen and uterus and into the fetal bladder, through which a 2.3 mm pigtail shunt is then passed. The shunt is placed as low in the bladder as possible to decrease the risk of displacement.

Once the shunt is placed and functioning properly, patients return home for the remainder of the pregnancy. Our team works closely with referring physicians to ensure the shunt is working properly and remains in place, as it can migrate into the abdomen or the amniotic space, which may require replacement in up to 40 percent of cases.

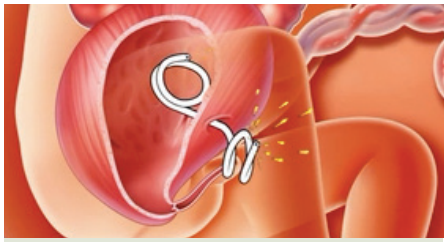
Some families choose to deliver in CHOP's Garbose Family Special Delivery Unit (SDU) because of the need for neonatal subspecialty care including urology, nephrology and neonatology. The SDU was designed specifically for pregnancies complicated by birth defects and offers the highest level of immediate care for the newborn, as well as expert obstetric services for the mother.

After delivery, babies are stabilized and transported to the Newborn/Infant Intensive Care Unit where they undergo imaging studies of kidney and bladder function that allow the urologists and nephrologists to counsel families on what they can expect in the short and long term. The team reinforces prenatal counseling and educates families about additional findings, if any, and how to manage the challenges their baby may face after discharge, such as urinary tract infections, poor bladder emptying and compromised renal function.

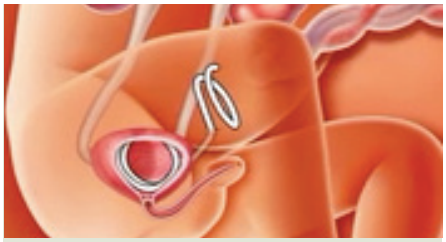
For posterior urethral valves, postnatal treatment typically involves ablation of the valves and removal of the shunt. In more complicated cases, a vesicostomy is performed to divert urine until the baby is healthy or old enough to undergo ablation, or urethral reconstruction is performed in cases of urethral atresia. Limited long-term outcome studies suggest that these pregnancies deliver on average at around 35 weeks, that only a third of the children went on to have complications resulting in end-stage renal disease and transplant, and two thirds were able to spontaneously void without need for catheterization. Follow-up involves outpatient clinic visits with urology and nephrology, typically every three months for the first year of life and regularly thereafter to monitor for kidney infections, renal insufficiency and bladder dysfunction.



Shunt is loaded into trocar, passed into bladder and recoils to pigtail shape.



Other end of shunt recoils to pigtail outside abdominal wall, releasing urine into amniotic fluid space around fetus.



Shunt is positioned as low in bladder as possible to decrease risk of displacement.

BY THE NUMBERS

CFDT Urologic Experience January 2001 to Present

Prenatal referrals: **1,254**

Fetal interventions: **202**

Postnatal surgeries: **3,735**

Fetal Interventions Offered:

- Amnioinfusion
- Fetal cystoscopy
- Vesicocentesis
- Vesico-amniotic shunt placement

Common Diagnoses:

- Lower urinary tract obstruction
- Hydronephrosis
- Ureteropelvic junction obstruction
- Urinoma
- Multicystic dysplastic kidney
- Exstrophy/epispadias
- Disorders of sex development

CASE STUDY: *Gender Discrepancy*

Maternal History: A 42-year-old G8P5116 female of Caucasian descent was evaluated at 22 weeks gestation due to a finding of gender discrepancy between karyotype and ultrasound. Routine amniocentesis, performed at 16 weeks gestation for advanced maternal age, documented a 46, XX, normal female karyotype, while the pre-procedural ultrasound evaluation showed normal male genitalia.

Given this scenario, what diagnoses should be considered in the differential?

1. Congenital adrenal hyperplasia (CAH)
2. 46, XX testicular disorder of sex development (DSD)
3. Maternal cell contamination (MCC)
4. Androgen insensitivity (AI)

Repeat amniocentesis, performed at 20 weeks gestation, confirmed the finding of a normal 46, XX karyotype and the presence of normal male external genitalia. Fluorescence *in situ* hybridization (FISH) studies demonstrated a copy of the SRY gene (sex-determining region of Y) on the short arm of one of the X chromosomes.

Evaluation: A detailed review of family, medical and pregnancy history was unremarkable for the presence of any known genetic conditions, structural anomalies and teratogenic exposures. Consanguinity was denied. Repeat targeted sonography revealed an appropriately grown fetus without apparent structural anomalies and normal-appearing male external genitalia.

Pregnancy and Delivery Course: The patient had a routine prenatal course and uneventful full-term vaginal delivery of a 3kg infant with normal external male genitalia. All newborn screening tests were within normal limits. A scrotal ultrasound revealed normally appearing bilaterally descended testicles. No mullerian structures were identified on pelvic ultrasound. Infant and mother were discharged following a 48-hour hospital stay.

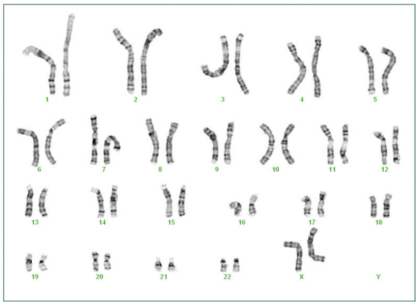
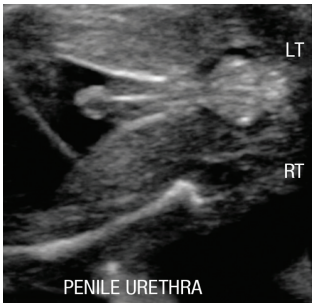


Image of a normal female karyotype
(provided by the CHOP Cytogenomics Laboratory)



Ultrasound image of normal appearing male genitalia

Questions

1. What additional studies, if any, might be considered?
2. How should this family be counseled?
3. What are the long-term implications of this diagnosis for this child?
4. Are there any other services that should become involved with this family?

For answers
fetalsurgery.chop.edu/casestudies

EDUCATIONAL RESOURCES

See these videos at fetalsurgery.chop.edu. Request copies of the DVDs at 1-800-IN UTERO (468-8376).

NOW AVAILABLE

Pathway to Hope: *Understanding Lower Urinary Tract Obstructions*

Birth of a Breakthrough: *Fetal Surgery for Spina Bifida*

ONLINE CONTINUING EDUCATION

The Center for Fetal Diagnosis and Treatment offers a variety of free online continuing education courses for physicians and nurses. To view our current offerings, including our newest courses, ***Fetal Myelomeningocele Repair: Tribulations and Trials*** and ***Managing Ventral Wall Defects: From Womb to Home***, please go to **fetalsurgery.chop.edu/fetal-ed**.

UPCOMING CONFERENCES: MEET OUR TEAM MEMBERS

NSGC 2011 Annual Education Conference
October 27–30, 2011, San Diego, CA

10th World Congress of Perinatal Medicine
November 8–11, 2011, Uruguay

Hot Topics in Neonatology
December 4–6, 2011, Washington, D.C.

SMFM 32nd Annual Meeting
February 6–12, 2012, Dallas, TX

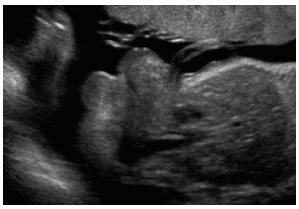
To access past issues of *In Utero Insights* covering clinical and research advances in prenatal spina bifida surgery, ventral wall defects and twin-twin transfusion syndrome, visit fetalsurgery.chop.edu and click on Professional Resources.

Caring for Children with the Exstrophy/Epispadias Complex

By Nahla Khalek, M.D., M.P.H., Douglas Canning, M.D., and Aileen Schast, Ph.D.

Bladder exstrophy is a severe developmental disorder in which the bladder protrudes inferior to umbilical cord insertion and separation of the pubic bones results in divergence of the rectus muscles. In males, epispadias of the urethra, where the meatus is on the top of the penis and creates a gutter from the point of the opening to the tip of the glans, is also part of the condition.

Prenatally, bladder exstrophy is suspected when there is notation of an absent bladder, but normal amniotic fluid volume, in conjunction with a lower midline ventral wall mass, abnormal appearing genitalia and bony pelvis malformation. The key defining ultrasound feature is a lower abdominal wall deformity with a low cord insertion that is cephalad to the exstrophied bladder. The fetal kidneys are usually sonographically normal.

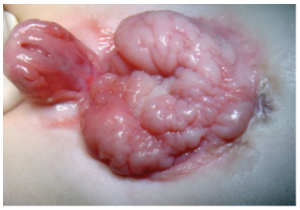


The Center for Reconstructive Surgery within The Children's Hospital of Philadelphia's Division of Urology is a specialized program for children with bladder exstrophy and epispadias. The Center also follows children who have isolated epispadias without exstrophy of the bladder, as they will need reconstructive surgery on the penis and urethra and may have challenges with continence. The Center's surgical team includes two urologists, an orthopaedic surgeon and an anesthesiologist who work together to do Complete Primary Repair of Bladder Exstrophy (CPRE), meaning the bladder is closed at the same time the urethra is reconstructed. The goal of this surgery, which typically occurs four to six weeks after birth, is to have the bladder fill and empty normally to preserve function.

Osteotomies, where the pubic bones are cut, rotated and set in a more optimal position to support the bladder, are also usually performed at this time.

The Center has surgically reconstructed 14 children with bladder exstrophy and 11 children with epispadias since 1996 using the CPRE.

- Of the 14 with bladder exstrophy, 13 are older than toilet-training age. Two have had their bladders augmented with their colon and the bladder neck closed and they now empty the augmented bladder through clean intermittent catheterization. One child is an infant and too young to have continence assessed. The remaining patients are voiding with dry intervals, but have not achieved full continence, meaning they have some daytime dampness and some are also wet at night.



- Of the 11 with isolated epispadias, seven are older than toilet-training age. None has undergone secondary bladder neck reconstruction. All are voiding with dry intervals and five of the seven are completely dry day and night. Having an orthopaedist perform osteotomies at the first surgery makes a difference in long-term continence, especially for these patients.

After the initial surgery, the Center follows these children and their families closely, obtaining regular renal bladder ultrasounds and tracking continence over time. Use of bulking agents to improve resistance at the bladder neck has helped children achieve a social level of dryness without the need for a large augmentation procedure. A pediatric psychologist in the Division of Urology works with children and their parents throughout their care at CHOP to facilitate coping and adjustment to this chronic condition.

NEWS FROM THE FETAL HEART PROGRAM

Study: Fetal Cardiovascular Effects of LUTO with Giant Bladder

Rychik J, McCann M, Tian Z, Bebbington M, Johnson MP. **Fetal cardiovascular effects of lower urinary tract obstruction with giant bladder.** *Ultrasound Obstet Gynecol* 2010; 36(6): 682-6.

Lower urinary tract obstructions (LUTO) with massive bladder distension affect a variety of developing organ systems with consequent morbidity and mortality. Yet, the impact of LUTO on the fetal cardiovascular system has not previously been investigated.

Jack Rychik, M.D., director of CHOP's Fetal Heart Program, recently led a study investigating the cardiovascular consequences of LUTO in the fetus. The study specifically examines the impact of a giant bladder on flow characteristics in the descending abdominal aorta to determine if a giant, distended bladder within the pelvis causes vascular compression with observable consequences.

Fetal echocardiography was performed in 42 fetuses with LUTO and a distended bladder and was compared to 35 normal controls matched for gestational age. Parameters investigated were cardiothoracic ratio, presence or absence of ventricular hypertrophy, and pericardial effusion. Doppler echocardiographic examination of mitral and tricuspid valve inflow and the ductus venosus was performed. To assess arterial vascular impedance, pulsatility indices (PIs) were calculated for segments of the descending aorta and right and left iliac arteries (RIA and LIA). The study yielded subtle, but potentially important, cardiovascular findings in the LUTO group. An increased cardiothoracic ratio was seen in nine (21%), ventricular hypertrophy in 12 (29%) and small pericardial effusion in 15 (36%). Filling characteristics of the right ventricle in the LUTO group demonstrated greater dependency upon atrial contraction and ductus venosus flow demonstrated higher downstream impedance to filling than in controls, suggesting diminished right ventricle compliance. The LUTO group also had lower distal descending aorta, lower RIA-PI and lower LIA-PI than controls, suggesting vascular compression and increased impedance to flow.

These findings show LUTO with giant urinary bladder compresses the iliac arteries, which may lead to increased afterload on the fetal heart, with consequences for the right ventricle. It reinforces CHOP's use of fetal echocardiography, with attention to flow in the lower descending aortic arterial tree, in the evaluation of fetuses with LUTO. Rychik hopes to further study the impact of fetal treatment such as bladder drainage on these cardiovascular parameters.

Comprehensive Follow-up for Urologic Issues Associated with Spina Bifida

Congenital anomalies such as spina bifida can result in a wide range of urologic disorders and necessitate comprehensive, long-term management. At The Children's Hospital of Philadelphia, experienced, carefully coordinated follow-up to meet the complex needs of patients and their families is a hallmark of our care.

A new breakthrough at CHOP offers the option of prenatal surgery and dramatically improved outcomes to families faced with myelomeningocele (MMC), the most common and serious form of spina bifida. Yet, children who receive pre- or postnatal surgery may have bowel and bladder incontinence after birth. CHOP's Spina Bifida Clinic is the nation's first program to bring a multidisciplinary approach to long-term follow-up for these patients and has the greatest collective experience in their care.

> *"We do our best to prepare families for what this condition means long-term, so they have a better understanding about what the issues going forward will be."*
>
> — Michael Carr, M.D., Ph.D., associate director of Urology

Urologic follow-up begins at birth and consists of renal and bladder ultrasound, urinalysis, urine culture, and antibiotic prophylaxis. Children who are followed at CHOP return at two months of age for a comprehensive appointment that involves a video urodynamic study. Subsequent visits occur every six months until age 2, then annually. Periodic urodynamic testing and renal bladder ultrasounds are performed to make sure the kidneys are functioning properly and that bladder function has remained stable. For families returning home for postnatal care, the team does an initial consult and babies are referred to appropriate programs near their home.

Protocols based on extensive experience and prior outcomes ensure all patients receive standardized care, with finer details of follow-up tailored to each child's condition. In addition to the core team of pediatricians, nurses, physical therapists, social workers, orthopaedic surgeons, urologists and neurosurgeons, children frequently require the services of other divisions within CHOP including Ophthalmology, Plastic Surgery, Endocrinology, Gastroenterology, General Surgery, Outpatient PT, Neuropsychology and Cardiology, as well as bracing and/or wheelchair fitting. The team arranges referrals for additional consultations with CHOP subspecialists as needed, and helps manage families' expectations of their child's ability to successfully toilet train from initial consultation.

Typical therapy involves clean intermittent catheterization (CIC), along with medication that helps the bladder store urine at low pressure. The team coordinates obtaining necessary supplies and instructs families — and, when older, children — on how to perform CIC. Orthopaedists and physical therapists assist patients who require bracing in working around issues that can affect their ability to self-catheterize.

The circle of care is continued through close communication with pediatricians. In many cases, our team manages follow-up well into adulthood — our oldest patients are now in their 40s. Nurses and social workers help patients and families navigate issues from accessing appropriate community services to enrolling in school, preparing school nurses to help with catheterization, if necessary.

"The level of customer service that we provide really sets us apart," says Michael Carr, M.D., Ph.D., associate director of Urology. "These are all of the things you have to take into consideration with these patients."

Specialized Programs that Enhance Urology Care at CHOP

The Division of Urology at The Children's Hospital of Philadelphia benefits from several specialized programs to help meet patients' needs.

Spina Bifida Clinic
For the care of children with neurogenic bladder and bowel.

Center for Minimally Invasive Surgery
For problems that can be treated with small incisions for a quick recovery.

DOVE Center – For treating problems related to continence and recurrent urinary tract infections.

Stone Center – For treating children with kidney stones.

Center for Reconstructive Surgery – For children with complex surgical needs, such as exstrophy, epispadias and hypospadias.

Program for Children with Disorders of Sex Development – For children with ambiguous genitalia or diagnosed disorders of sex development (DSD).

For more information on specialized urology care at CHOP, visit **www.chop.edu/urology**.

RESEARCH UPDATE

LUTO with Normal Amniotic Fluid Volume: Understanding Outcomes to Improve Care

Invasive fetal therapy for lower urinary tract obstructions requires the presence of oligohydramnios to justify the risks of *in utero* therapy. Prenatal intervention in these carefully selected cases has resulted in improved survival and pulmonary outcomes, with secondary improvement in renal outcomes. But little is documented about the natural history and morbidity or mortality of fetuses with early midgestational LUTO and normal amniotic fluid volume.

The Center for Fetal Diagnosis and Treatment is the coordinating center for a study on outcomes of fetuses with prenatally diagnosed but untreated LUTO and normal amniotic fluid volume prior to 24 weeks gestation. The study, led by Mark P. Johnson, M.D., director of obstetric services for the Center, includes participation from 12 North American Fetal Therapy Network hospitals across the United States and Canada. If a significant proportion of these infants are found to have impaired pulmonary and bladder function and renal impairment requiring medical or surgical kidney replacement therapy, it may justify fetal intervention in the presence of normal amniotic fluid levels.

Recorded data includes prenatal ultrasound and delivery information, and an annual review of infant medical, surgical and developmental status based on phone surveys and requested clinical information from the family, primary pediatrician and urology specialist for the first two years of life. The study team also hopes to identify prenatal sonographic markers that might help differentiate fetuses with poor postnatal outcomes from those with good postnatal outcomes.

Twenty-five patients have been enrolled in the study since recruitment began five years ago, demonstrating just how rare these cases are. A recent interim analysis of outcomes supports continued recruitment.

If you would like to enroll a patient or for more information, please call 1-800-IN UTERO (468-8376).

Natural history registry for pregnancies complicated by prenatally diagnosed lower urinary tract obstructions (LUTO) with normal amniotic fluid volume

Principal Investigator: Mark P. Johnson, M.D.

Status: IIRB approved; actively enrolling patients and collecting data

Type of Study: A natural history registry for patients with LUTO and normal amniotic fluid, prospective data collection

Design: Currently, invasive fetal therapy for LUTO requires the presence of oligohydramnios to justify the risks of *in utero* therapy. The primary aims of this study are to determine if fetuses with prenatally diagnosed but untreated LUTO and normal amniotic fluid volume prior to 24 weeks gestation have impaired renal function after birth and determine if there are prenatal sonographic markers that might help differentiate fetuses with poor postnatal outcomes from those with good postnatal outcomes.

RECENT PUBLICATIONS

from CHOP's experience with congenital urologic defects

Lambert SM, Snyder HM 3rd, Canning DA. **The history of hypospadias and hypospadias repairs.** *Urology.* 2011 Jun;77(6):1277-83. Epub 2011 Apr 15. PMID: 21497381 [PubMed - in process]

Kraft KH, Shukla AR, Canning DA. **Proximal hypospadias.** *ScientificWorldJournal.* 2011 Apr 19;11:894-906. PMID: 21516286 [PubMed - in process]

Rychik J, McCann M, Tian Z, Bebbington M, Johnson MP. **Fetal cardiovascular effects of lower urinary tract obstruction with giant bladder.** *Ultrasound Obstet Gynecol.* 2010 Dec;36(6):682-6. doi: 10.1002/uog.7664. Epub 2010 Apr 20. PMID: 20503245 [PubMed - indexed for MEDLINE]

Carr MC, Kim SS. **Prenatal management of urogenital disorders.** *Urol Clin North Am.* 2010 May;37(2):149-58. Review. PMID: 20569794 [PubMed - indexed for MEDLINE]

Casale P. **Laparoscopic and robotic approach to genitourinary anomalies in children.** *Urol Clin North Am.* 2010 May;37(2):279-86. Review. PMID: 20569805 [PubMed - indexed for MEDLINE]

Kraft KH, Shukla AR, Canning DA. **Hypospadias.** *Urol Clin North Am.* 2010 May;37(2):167-81. Review. PMID: 20569796 [PubMed - indexed for MEDLINE]

Mann S, Johnson MP, Wilson RD. **Fetal thoracic and bladder shunts.** *Semin Fetal Neonatal Med.* 2010 Feb;15(1):28-33. Epub 2009 Jul 12. Review. PMID: 19596218 [PubMed - indexed for MEDLINE]

Wu S, Johnson MP. **Fetal lower urinary tract obstruction.** *Clin Perinatol.* 2009 Jun;36(2):377-90, x. Review. PMID: 19559326 [PubMed - indexed for MEDLINE]

Casale P, Meyers K, Kaplan B. **Follow-up for laparoscopic renal denervation and nephropexy for autosomal dominant polycystic kidney disease-related pain in pediatrics.** *J Endourol.* 2008 May;22(5):991-3. PMID: 18370613 [PubMed - indexed for MEDLINE]

Lassmann J, Sliwoski J, Chang A, Canning DA, Zderic SA. **Deletion of one SERCA2 allele confers protection against bladder wall hypertrophy in a murine model of partial bladder outlet obstruction.** *Am J Physiol Regul Integr Comp Physiol.* 2008 Jan;294(1):R58-65. Epub 2007 Oct 31. PMID: 17977917 [PubMed - indexed for MEDLINE]

Carr MC. **Fetal myelomeningocele repair: urologic aspects.** *Curr Opin Urol.* 2007 Jul;17(4):257-62. Review. PMID: 17558269 [PubMed - indexed for MEDLINE]

Kutikov A, Nguyen M, Guzzo T, Canter D, Casale P. **Laparoscopic and robotic complex upper-tract reconstruction in children with a duplex collecting system.** *J Endourol.* 2007 Jun;21(6):621-4. PMID: 17638558 [PubMed - indexed for MEDLINE]

Schwab CW 2nd, Hyun G, Garibay-Gonzalez F, Canning DA, Grady RW, Casale P. **Transperitoneal laparoscopic pyeloplasty for pelvic kidneys with ureteropelvic junction obstruction in children: technique and preliminary outcomes.** *JSLS.* 2006 Jul-Sep;10(3):307-9. PMID: 17212885 [PubMed - indexed for MEDLINE]

Gonzalez F, Canning DA, Hyun G, Casale P. **Lower pole pelvi-ureteric junction obstruction in duplicated collecting systems.** *BJU Int.* 2006 Jan;97(1):161-5. PMID: 16336349 [PubMed - indexed for MEDLINE]

Canning DA. **Gender assignment in female congenital adrenal hyperplasia: a difficult experience.** *J Urol.* 2005 Nov;174(5):2011-2. PMID: 16217380 [PubMed - indexed for MEDLINE]

Biard JM, Johnson MP, Carr MC, Wilson RD, Hedrick HL, Pavlock C, Adzick NS. **Long-term outcomes in children treated by prenatal vesicoamniotic shunting for lower urinary tract obstruction.** *Obstet Gynecol.* 2005 Sep;106(3):503-8. PMID: 16135579 [PubMed - indexed for MEDLINE]

Kiddoo DA, Carr MC, Dulczak S, Canning DA. **Initial management of complex urological disorders: bladder exstrophy.** *Urol Clin North Am.* 2004 Aug;31(3):417-26, vii-viii. Review. PMID: 15313051 [PubMed - indexed for MEDLINE]

BEST CHILDREN'S HOSPITALS U.S.News & World Report HONOR ROLL 2011-12

Awarded the top spot on *U.S.News & World Report*'s elite Honor Roll.

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