Fetal uropathies
Prenatal imaging and post natal correlations

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No conflict of interest to declare

Background

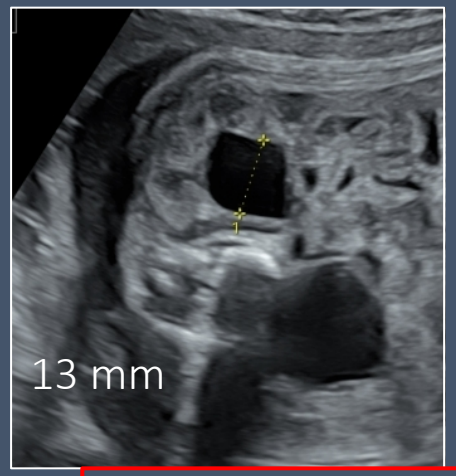
- Congenital anomalies of the kidneys and urinary tract (CAKUT) cover a wide spectrum of entities with different prognosis
- They occur in about 1 out of 250 births
- Most are benign, but others are the leading cause of paediatric end stage renal disease
- The role of prenatal imaging is

  > to depict those anomalies

  > to differentiate obstructive from refluxing or malformative uropathies, in order to optimise pre and post natal work up

Journal of Ultrasound 2019; 22:5-12
Front Pediatr 2019;7:103

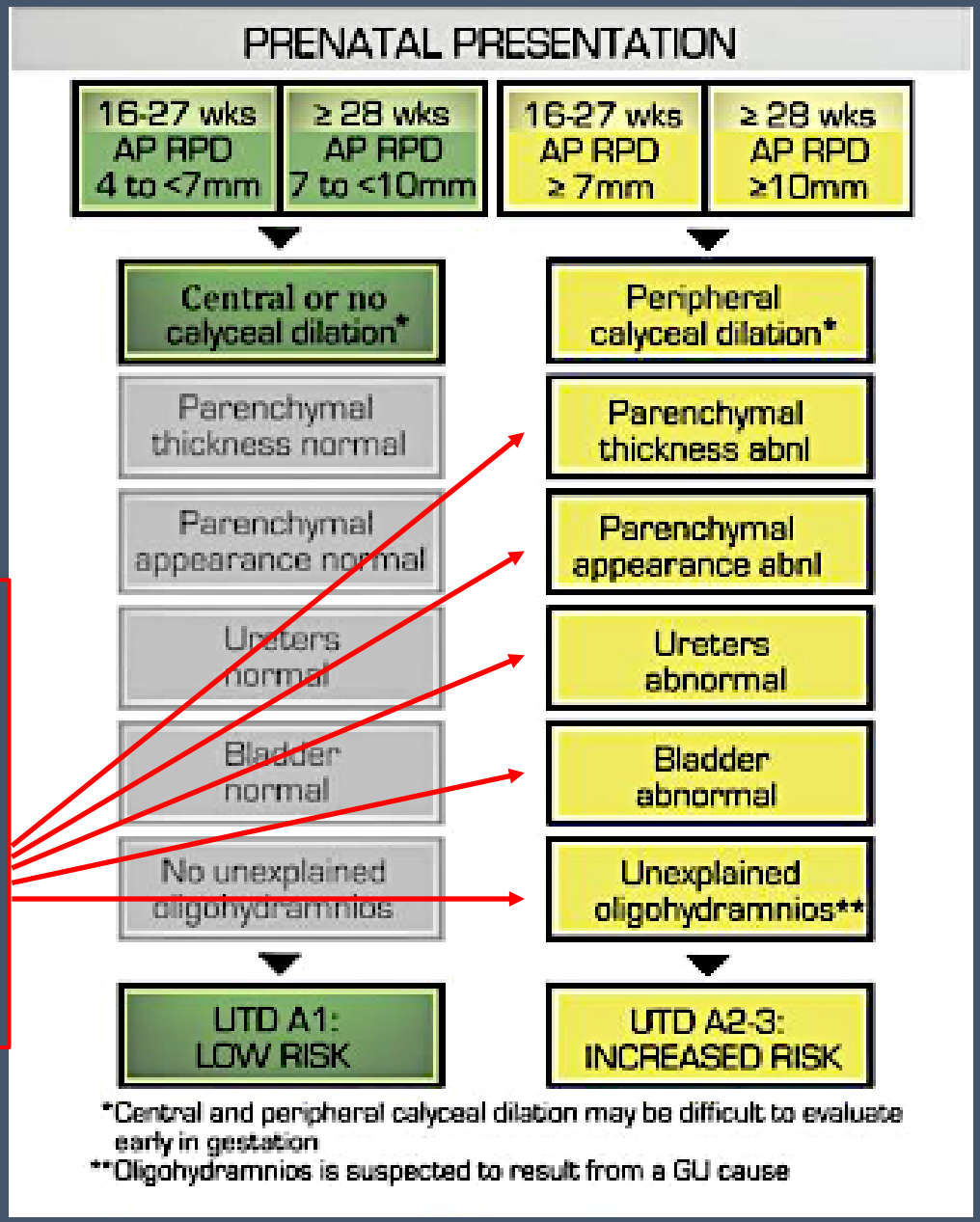
Pyelic dilation



- Isolated slightly increased APRPD
  APRPD 2nd trimester > 4mm max 7mm
  3rd trimester >7mm max 10mm
  >>>> low risk

- Significant increased APRPD or associated with other signs
  >>>> high risk

Most of mild pyelic dilation resolve spontaneously



Journal of Pediatric Urology 2014;10, 982e999
Pediatr Radiol 2022;52:740-751

Fetal uropathies

A. Upper urinary tract dilation

1. Obstructive uropathies
   - PUJS
   - Primary megaureter
2. Refluxing uropathies

B. Megacystis

- Differential diagnosis
- PUV

C. Other malformative uropathies

- MCKD
- Duplex kidneys
- Abnormal bladder > urogenital sinus
  > bladder exstrophy

1. Obstructive uropathies

PUJS

- Results from a functional (vascular extrinsic compression) or anatomical (valve, fibrosis) stenosis of the pelvi-ureteral junction leading to pelvicalyceal dilation and secondary parenchymal damage

> prenatal US diagnosis

huge pelvicalyceal dilatation, round shaped extra renal pelvis

aspect of the renal parenchyma (thinned, hyperechoic, cystic)

no visible ureters

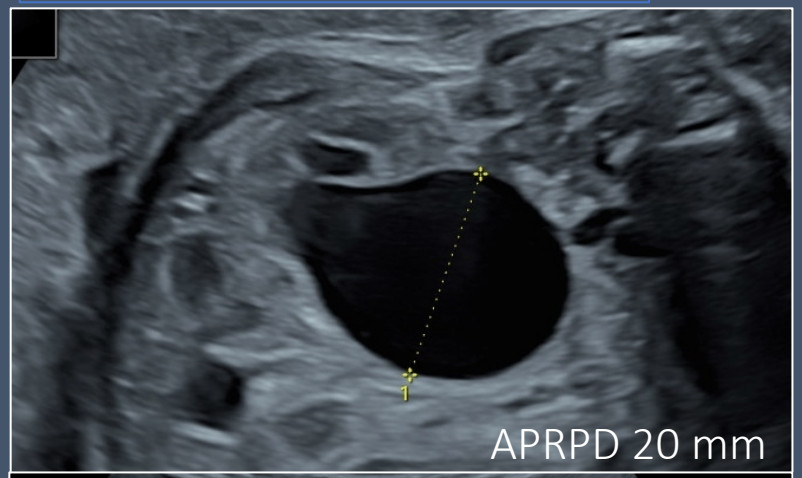
normal bladder

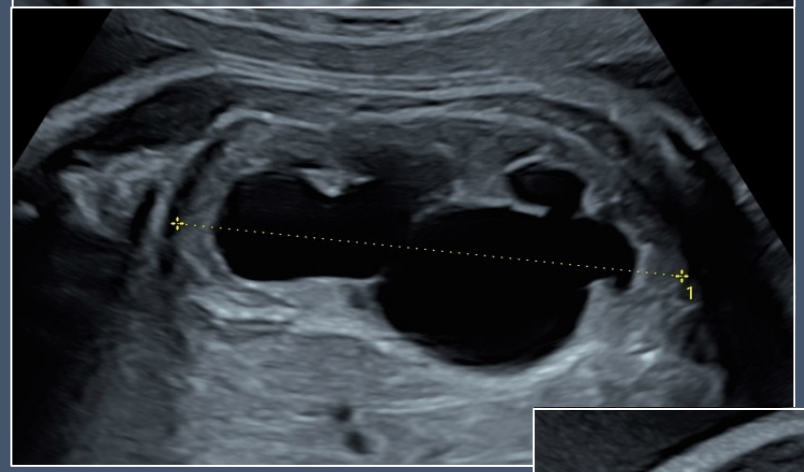
> prenatal follow-up advised every month to follow the dilation and the parenchymal aspect

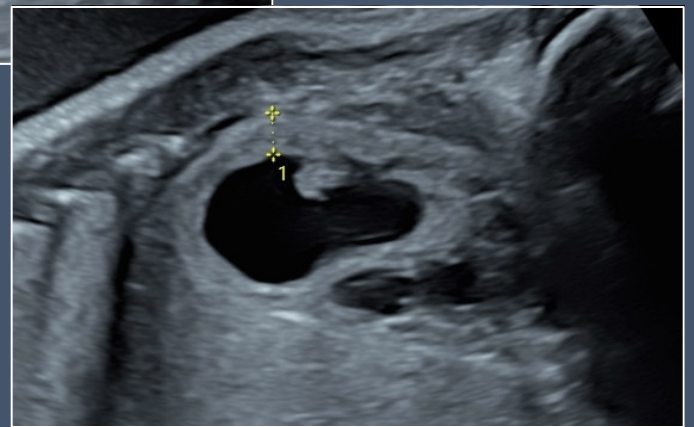
Pediatr Nephrol, 2018 33: 541-5

Unilateral PUJS

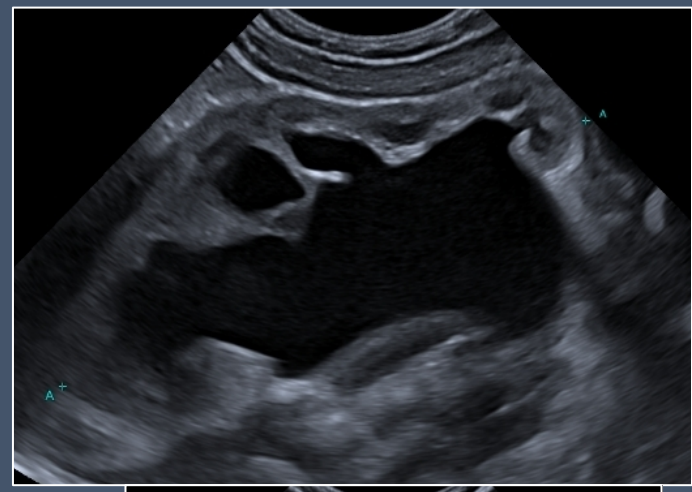
Prenatal imaging

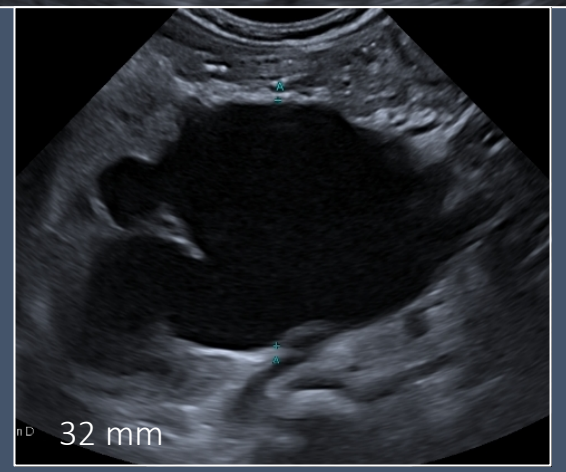




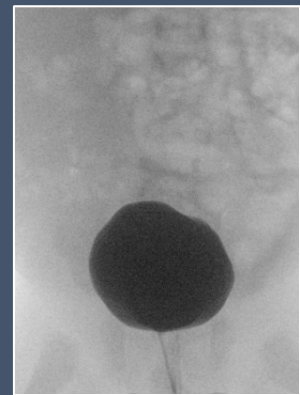


33 W Female fetus
Round shaped extra renal dilated pelvic cavity
Hyperechoic thinned renal cortex
No dilated ureters



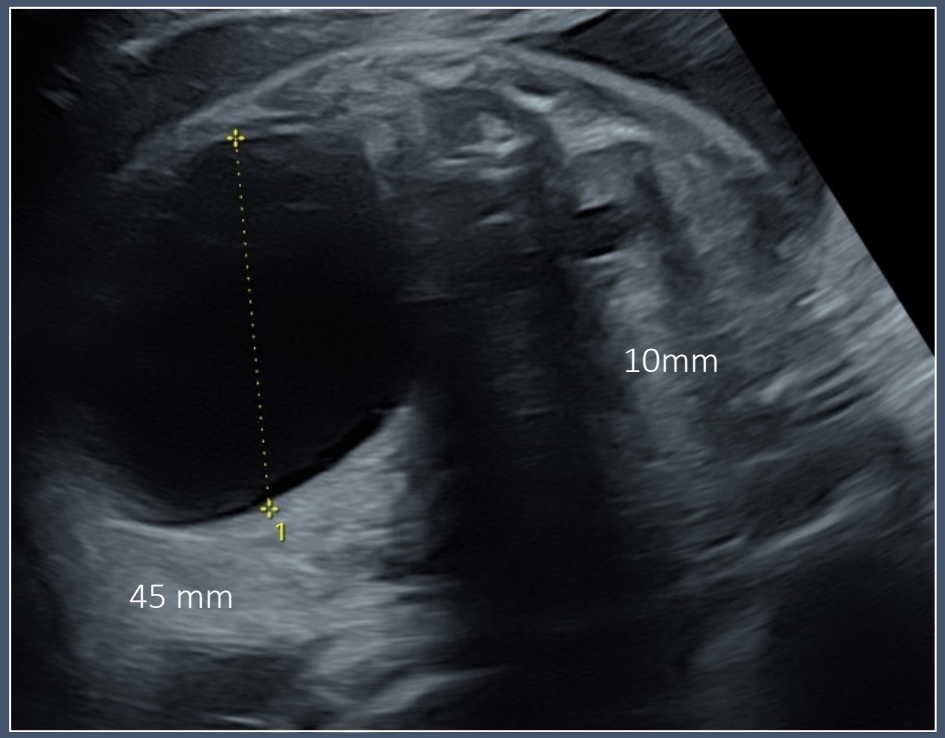


At birth
Uni lateral pyelo-ureteral junction stenosis
No reflux

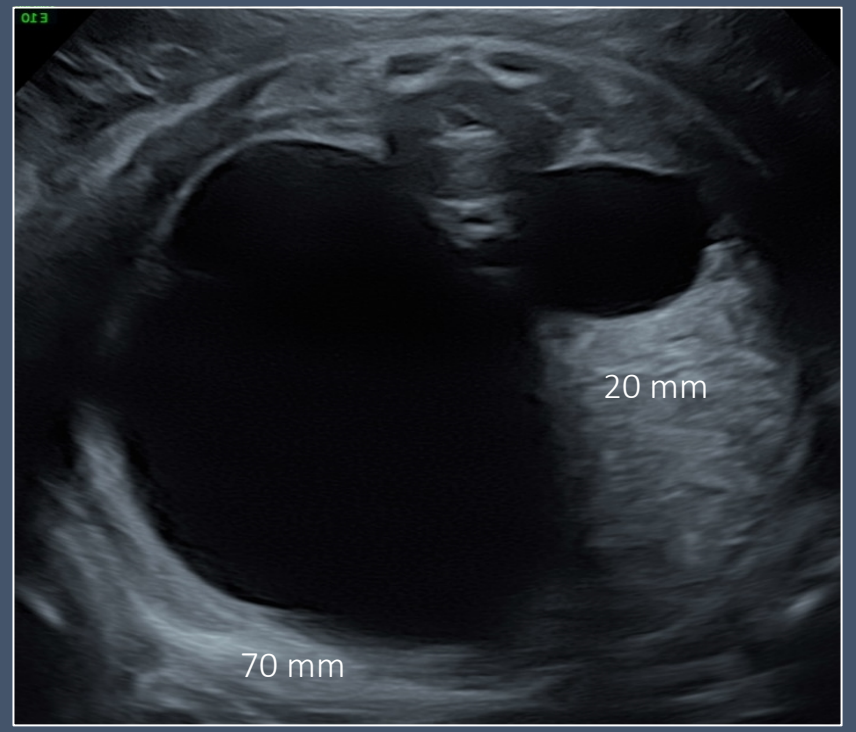


Bilateral PUJS

Prenatal imaging



30 W



34 W

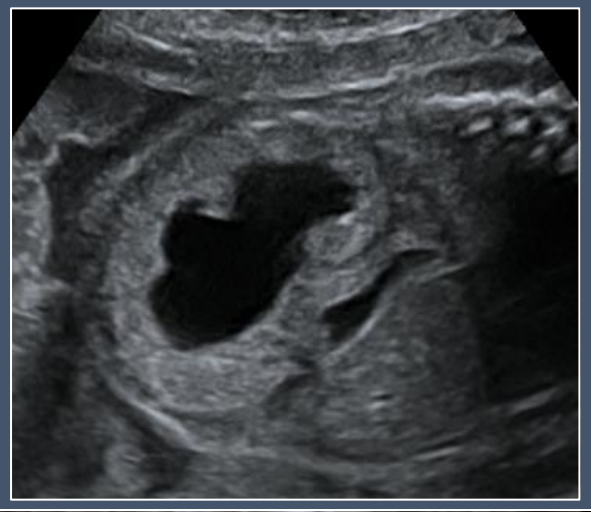
Male fetus

Progressively increased dilation in utero

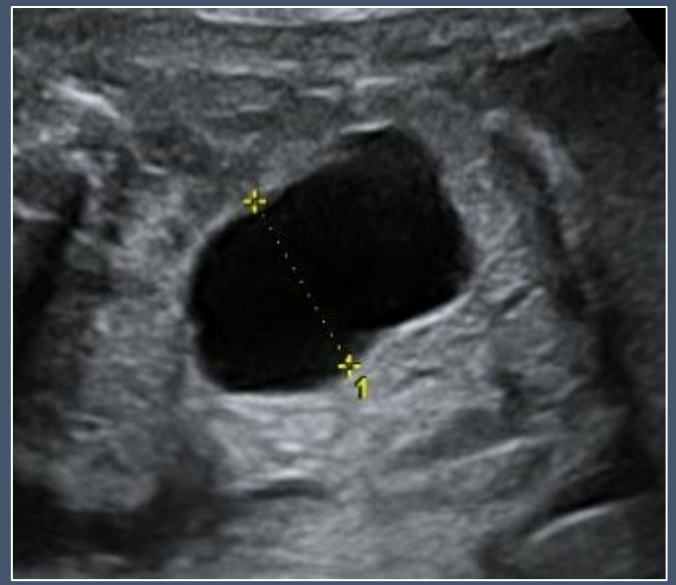
>>> Importance of prenatal follow-up to evaluate cavities dilation

Unilateral PUJS
Parenchymal damage

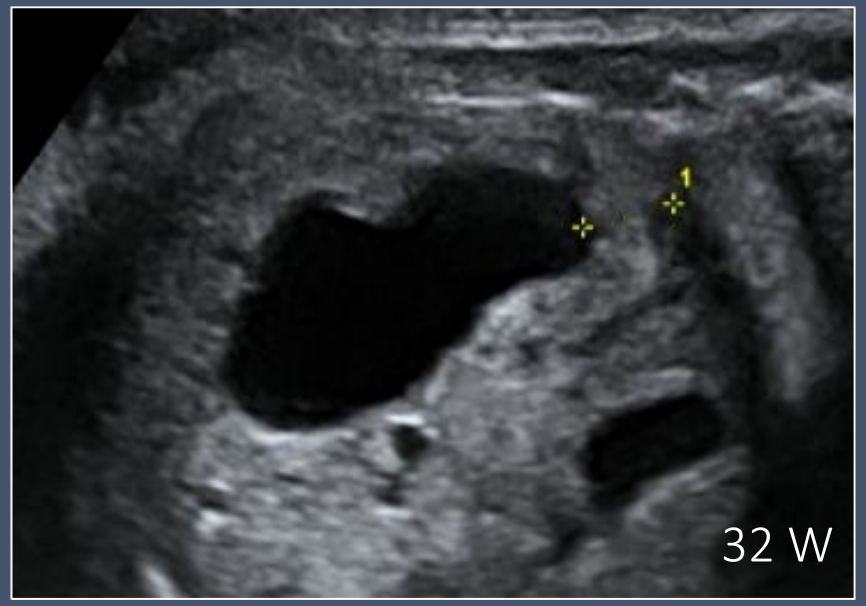
Prenatal imaging

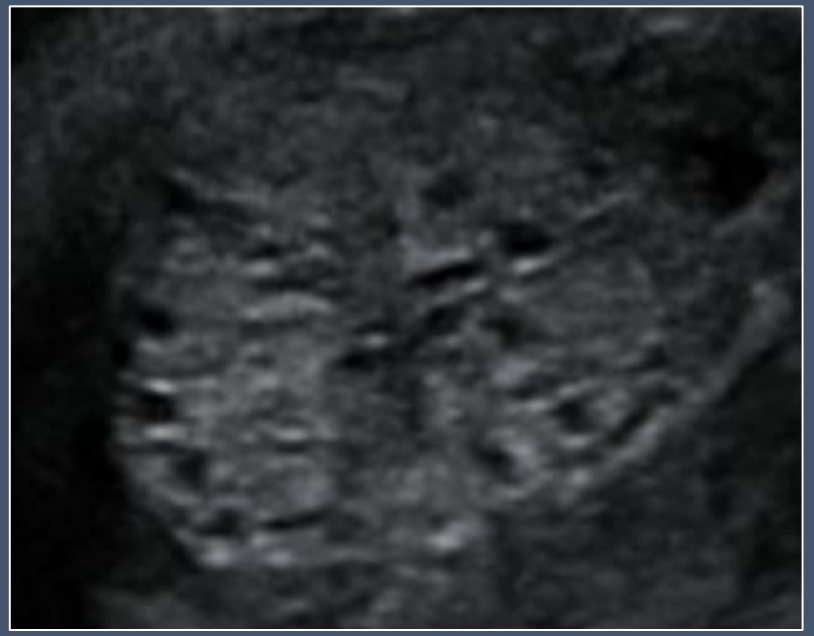


27 W
Female fetus



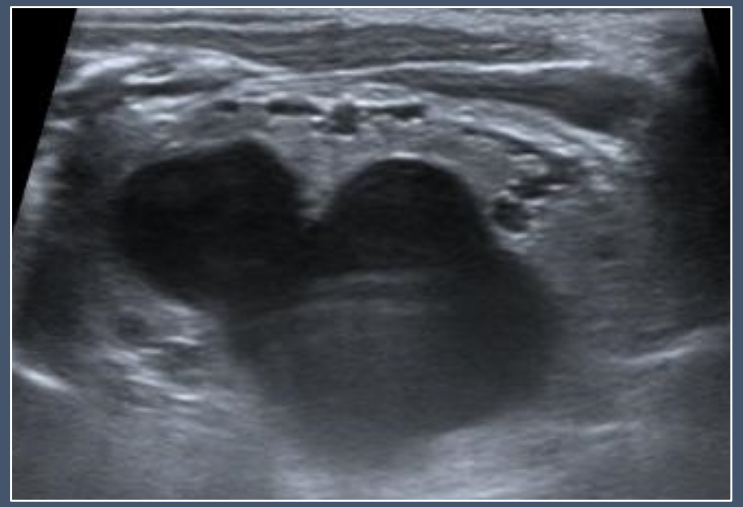
Obstructive cystic nephropathy

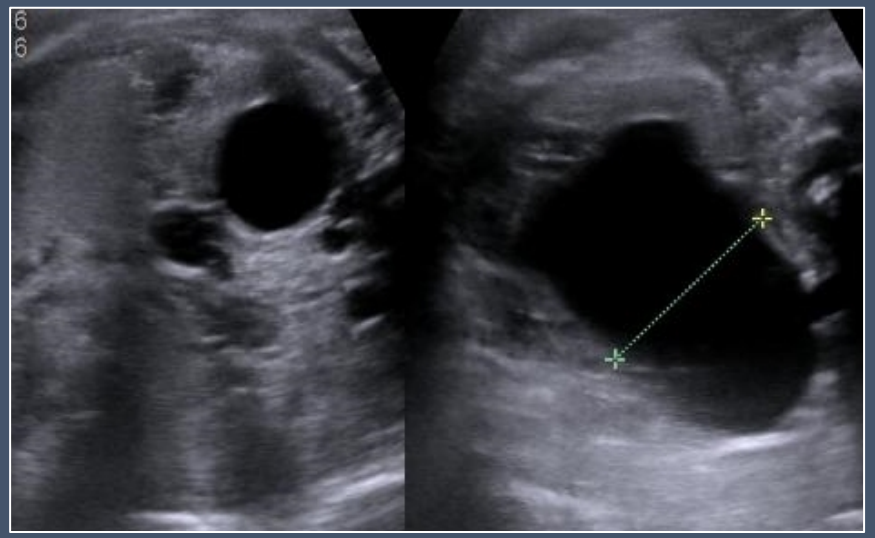




>>> Importance of prenatal follow-up to evaluate the renal parenchyma

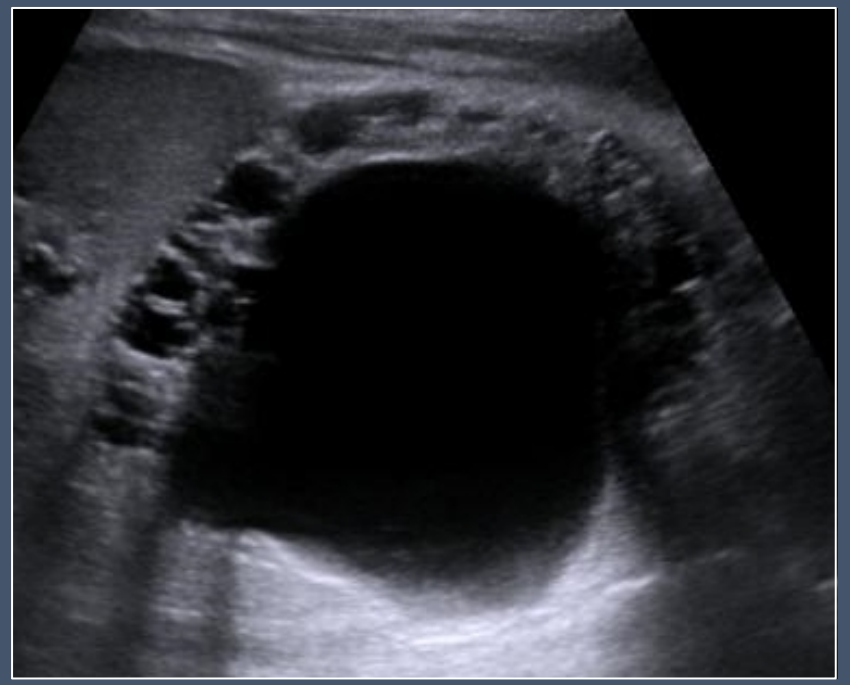
Unilateral PUJS
Parenchymal damage





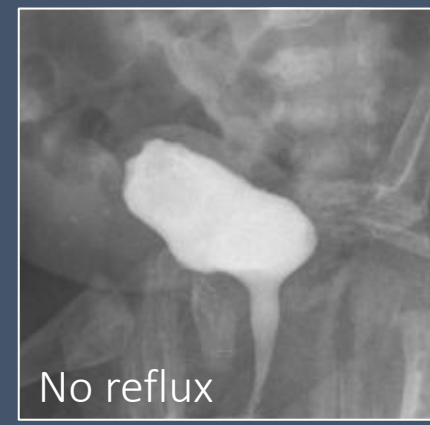
Neonatal US

Postnatal imaging



3 month

Progressive obstructive renal cystic dysplasia



No reflux

Obstructive uropathies (UPJS)
Post natal work-up

- Neonatal period

  > US to have a baseline of the pelvicalyceal dilation and parenchymal aspect

- Long term follow-up

  > repeated US at 1 month and every 3 months in the first year and then adapted according to the evolution

  > VCUG to exclude reflux (in cases with febrile infections)

  > functional assessment (isotopes) at 6 months or MRU (since 3 months) according to the parenchymal aspect and the dilation

ABP is controversial, its use may be limited to cases with recurrent infections

Conservative or surgical management is controversial (frequent spontaneous resolution)

>>> Globally, increasing cavities dilation, parenchymal renal deterioration and delayed cortical transit time should lead to consider surgical treatment

Pediatr Nephrol 2017;32:2203–13
Front Pediatr 2020; 8: 242
J Pediatr Urol 2014; 10:26-33

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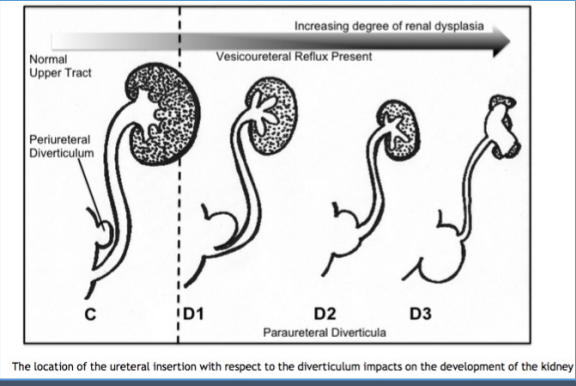
- Abnormal bladder > urogenital sinus
  > bladder exstrophy

2.Refluxing uropathies



The location of the ureteral insertion with respect to the diverticulum impacts on the development of the kidney

- VUR Is defined as a uni- or bilateral retrograde flow of urine from the bladder into the upper urinary tract. It is secondary to a dysfunction of the anti-reflux process at the uretero-vesical junction (ectopic insertion, short intra parietal portion, periureteral diverticulum)

> prenatal US diagnosis

fluctuating pelvic dilatation

pelvic or ureteral wall thickening

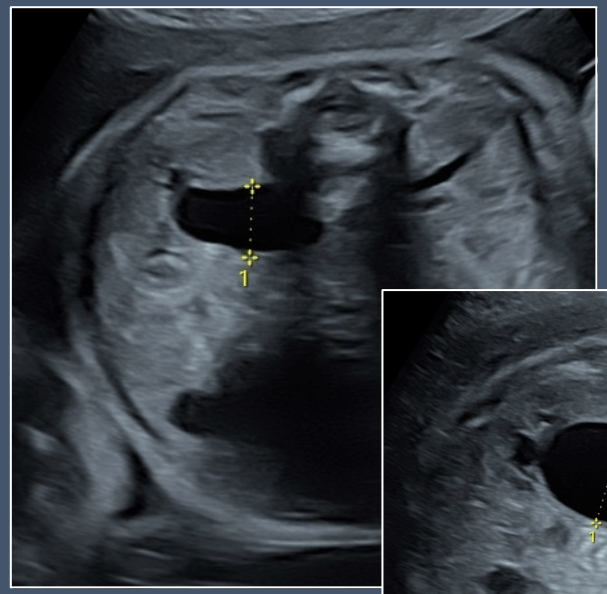
ureteral dilation

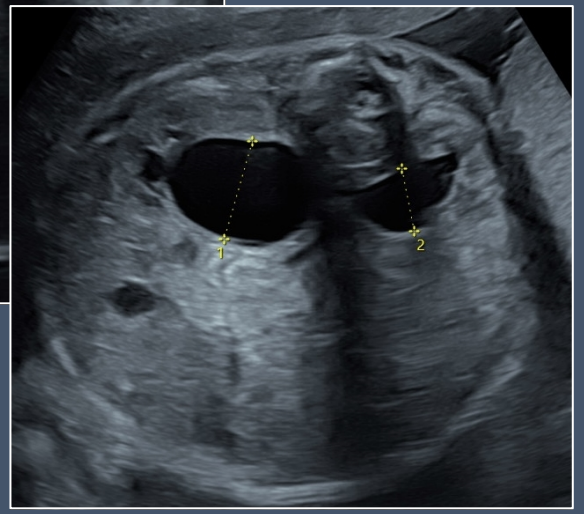
megacystis

hypodysplastic kidney (reflux nephropathy)

Pediatr Nephrol 2020; 35:2129–2135

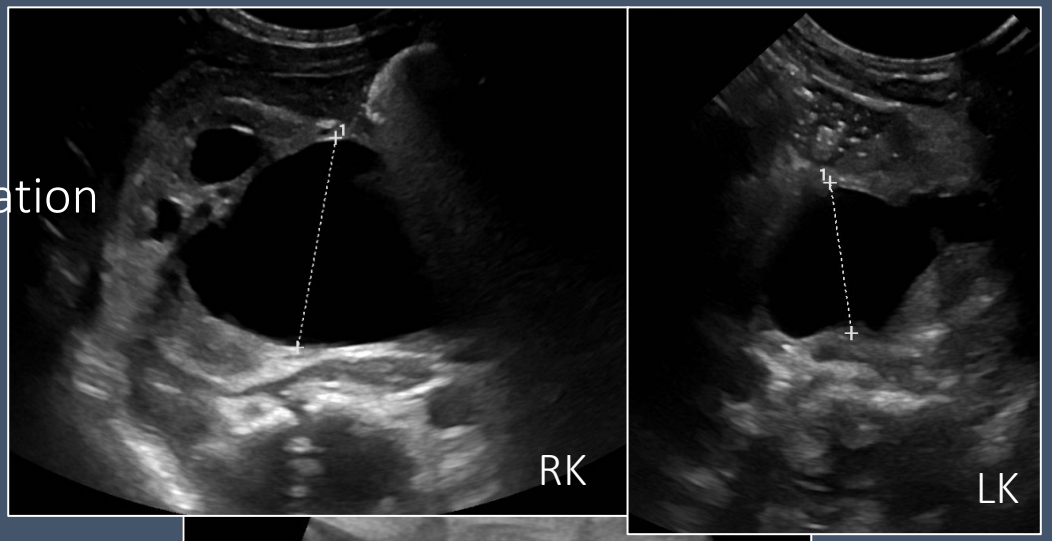
Bilateral reflux



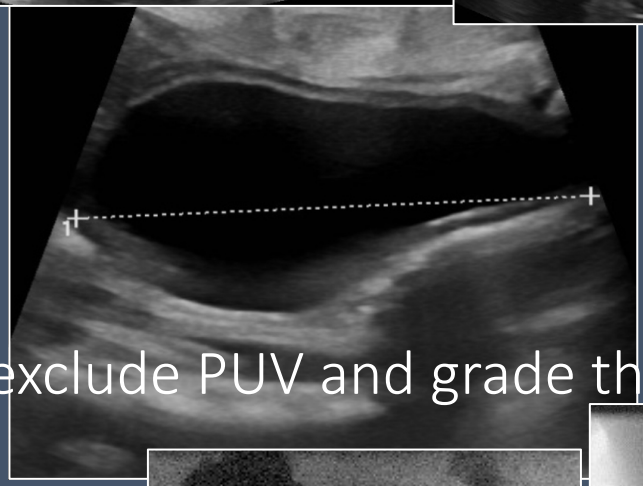


Bilateral pelvi-caliceal fluctuating dilation
Pyelic wall thickening
Fluctuating ureteral dilation
Megacystis

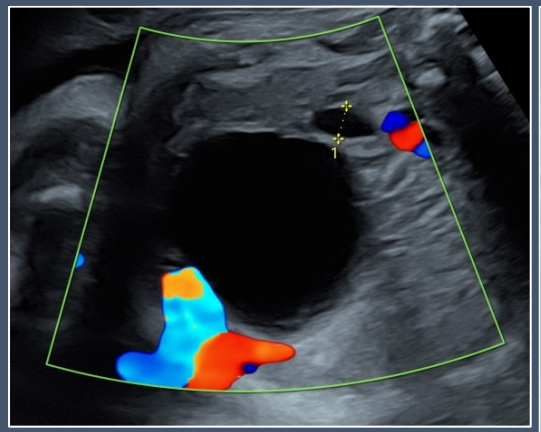
29 W
Male fetus

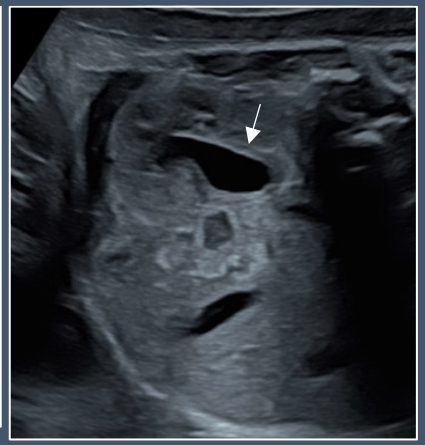


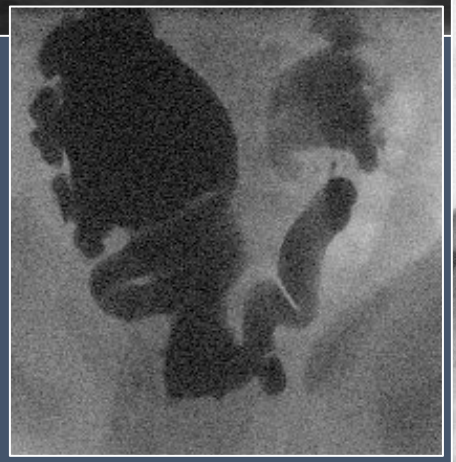
Neonatal work-up

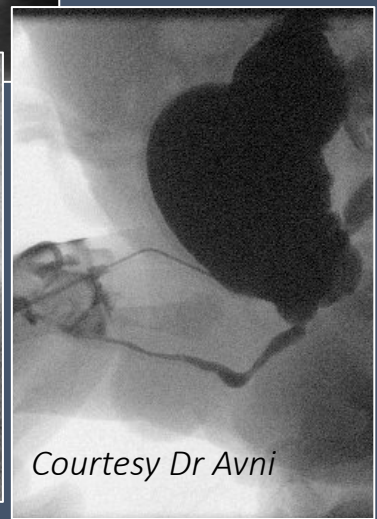


Neonatal VCUG to exclude PUV and grade the reflux



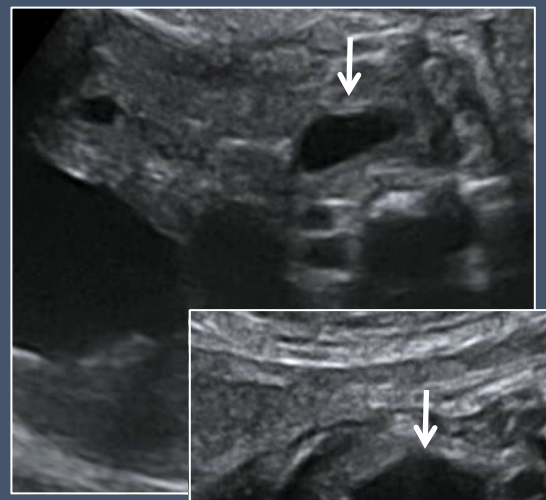


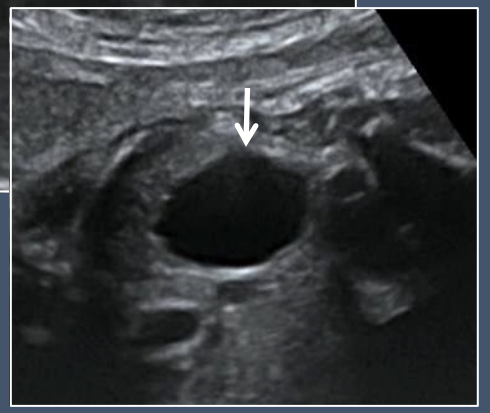




Courtesy Dr Avni

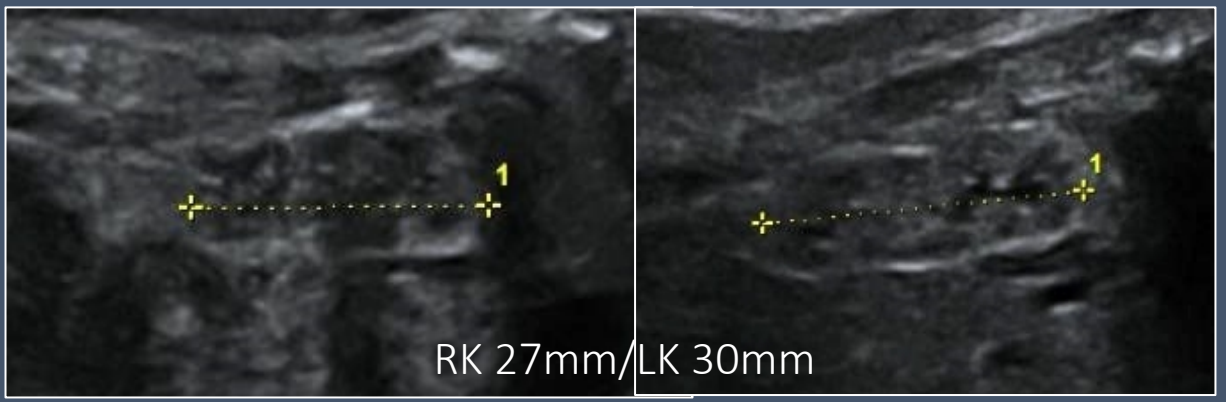
Bilateral reflux
Reflux nephropathy

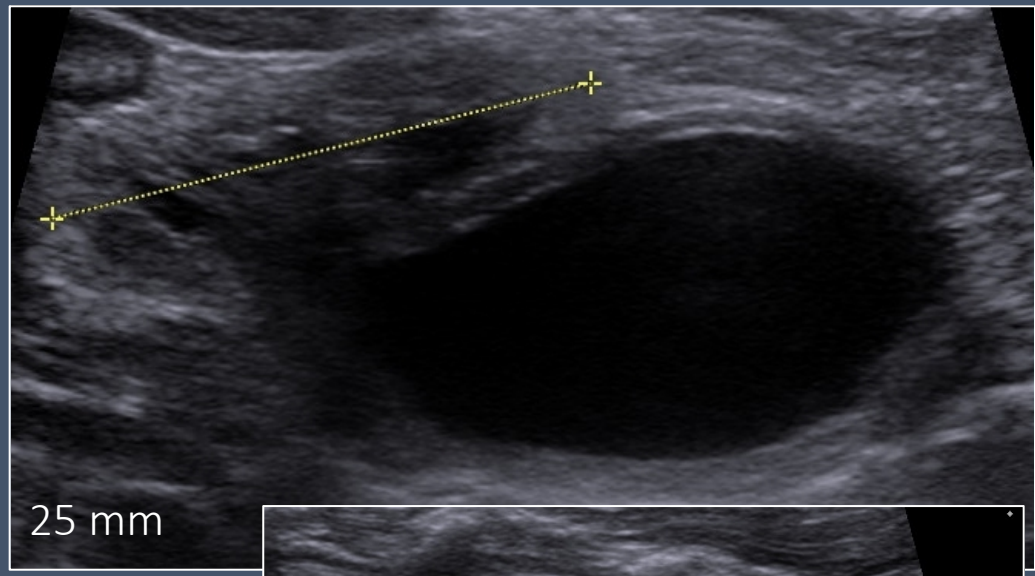


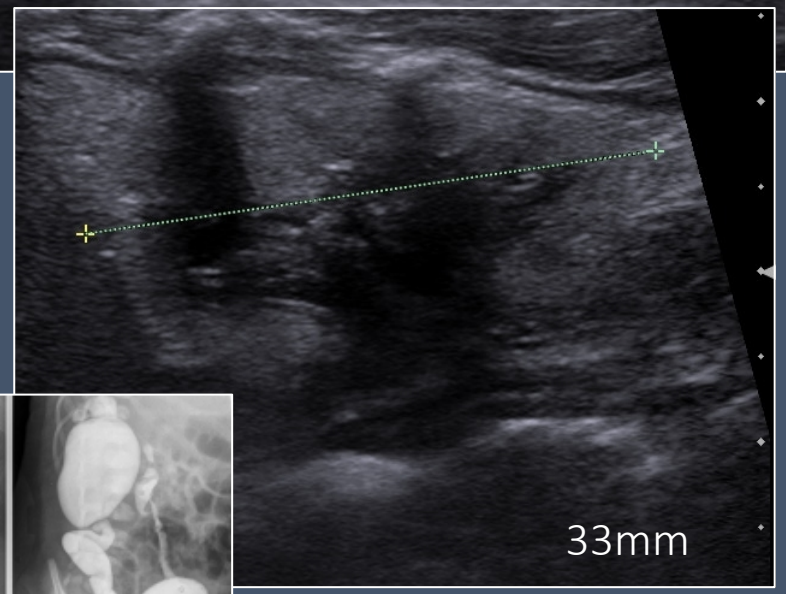


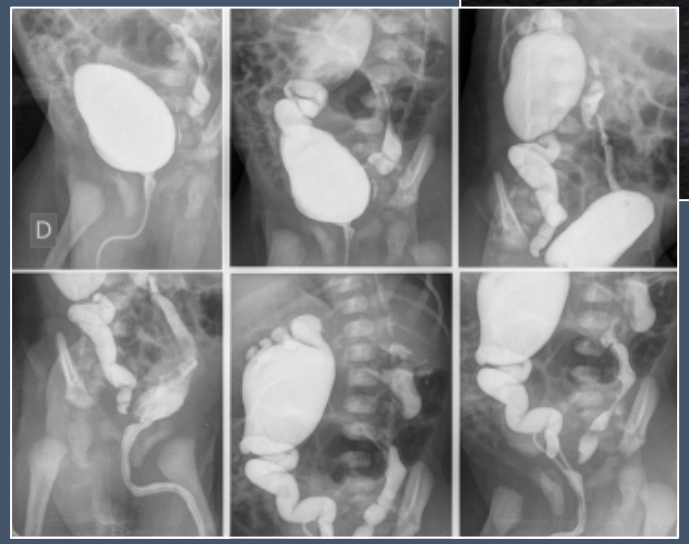
34 W Male fetus
Bilateral fluctuating dilation
Hypodysplastic kidneys
Reduced amniotic fluid

Renal hypodysplasia on VUR?









Neonatal work up
Bilateral reflux

Refluxing uropathies
Post natal work-up

- Neonatal period

> US (between the third and fifth days of life to avoid neonatal dehydration) to confirm the diagnosis, evaluate the pelvicalyceal dilation and appreciate renal parenchymal aspect

- Long term follow-up

> repeated US at 1 month and every 3 months in the first year and then adapted according to the evolution

> VCUG at one month to confirm/grade the reflux (if US shows suggestive signs)

No ABP is needed in asymptomatic patients with low grade reflux

ABP is advised in high grade reflux and surgical approach is proposed in cases with reccurent infection and renal damage (morphologic and functional data)

Eur Urol 2012;62:534–42

	US signs of obstruction	US signs of reflux
Kidneys - **Parenchyma**	Hyperechogenic, undifferentiated, cystic dysplasia	Small sized kidneys, undifferentiated
- **Cavities**	Non fluctuating dilated cavities, round shaped extra renal pelvis in PUJS, no parietal thickening	Fluctuating pyelocaliceal cavities, pyelic wall thickening
Ureters	Permanent dilation in VUJS, no dilation in PUJS	Fluctuating ureteral dilation
Bladder	Thickened wall in PUV	Often enlarged bladder
Urethra	Dilation of the posterior urethra in PUV	No dilation

Fetal uropathies

A. Upper urinary tract dilation
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      - Primary megaureter
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B. Megacystis
   - Differential diagnosis
   - PUV

C. Other malformative uropathies
   - MCKD
   - Duplex kidneys
   - Abnormal bladder > urogenital sinus
                      > bladder exstrophy

B. Megacystis

- The prenatal diagnosis of megacystis is evoked when the bladder's height is superior to 3 and 5 cm in the second and third trimester US, respectively, with subjective impression of persistent enlarged bladder without voiding cycles. Such presentation may be physiological or secondary to reflux or obstruction

> prenatal US diagnosis

enlarged bladder

thick or thin bladder wall (obstructive or not)

fetal pelvis anatomy

perineal view of the dilated urethra (PUV)

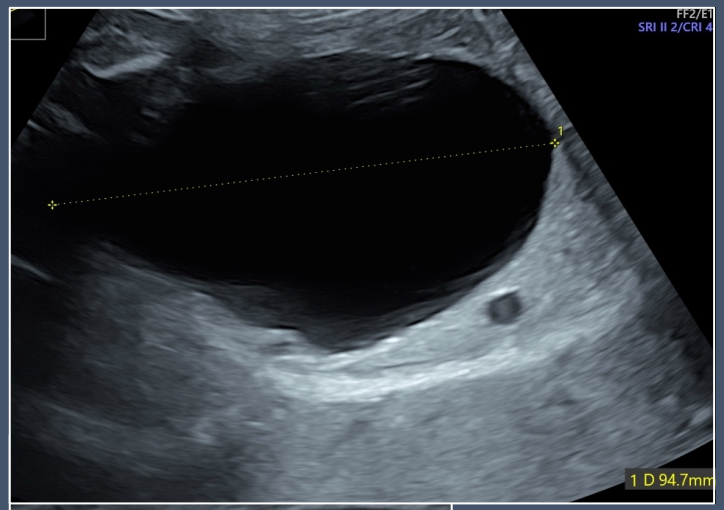
Ultrasound Obstet Gynecol 2019; 53:779-787

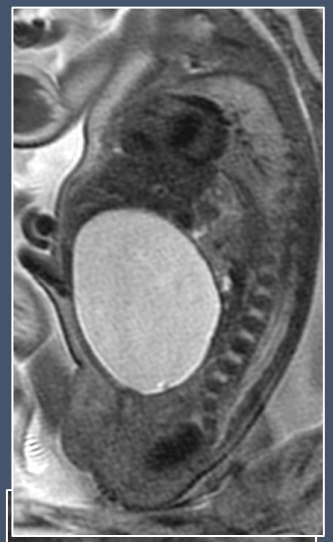
Megacystis
Etiologies

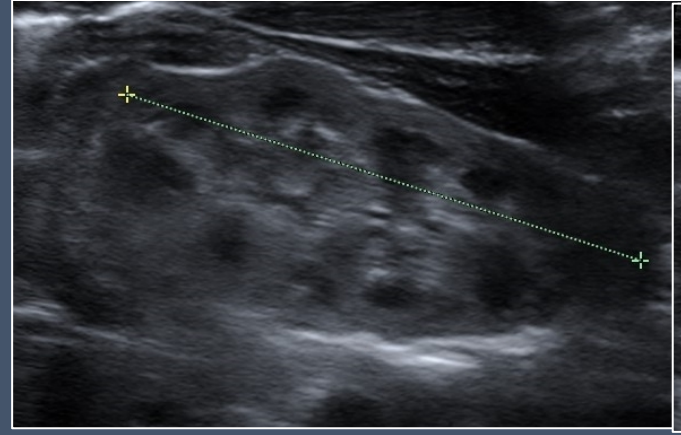
Megabladder of the second and third trimester

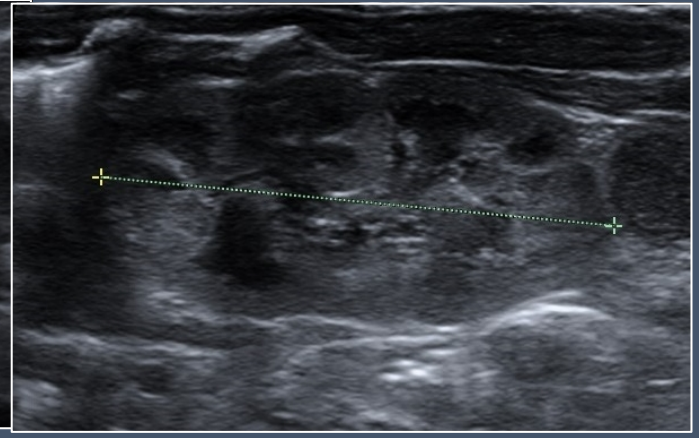
Physiologic	Female fetus- third trim- isolated
Medication	Antipsychotics or anticholinergics
Dysplastic	Megabladder-microcolon hypoperistalsis (F>M)
Obstructive	Urethral valves (male fetus)
	Prolapsed ureterocoele (renal duplication)
	Pelvic tumour (teratoma)
Refluxing	Bladder decompensation - megaureters

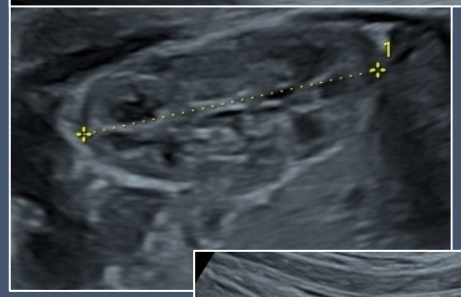
Physiological megacystis



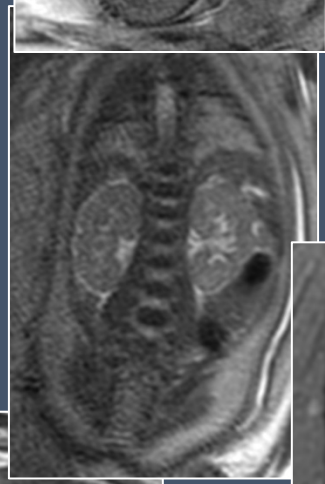


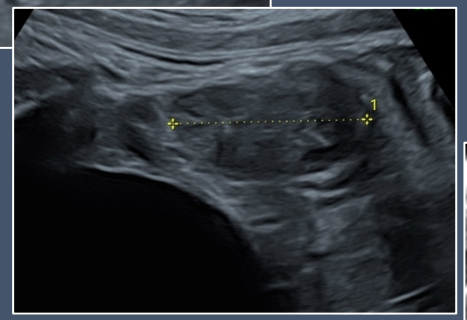


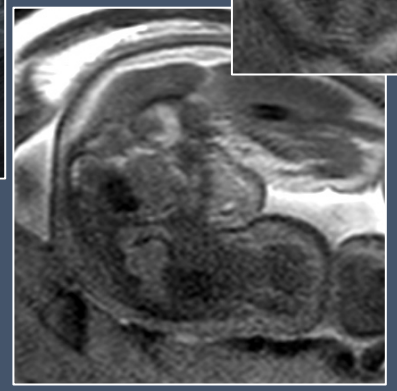


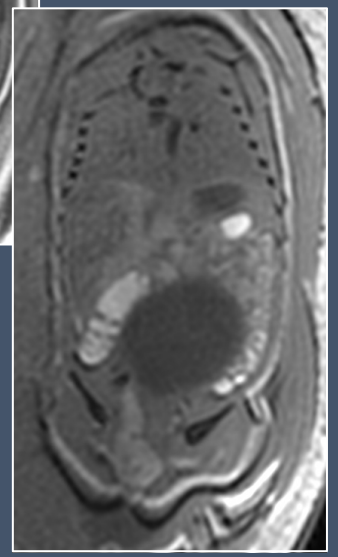


34 W
Female fetus

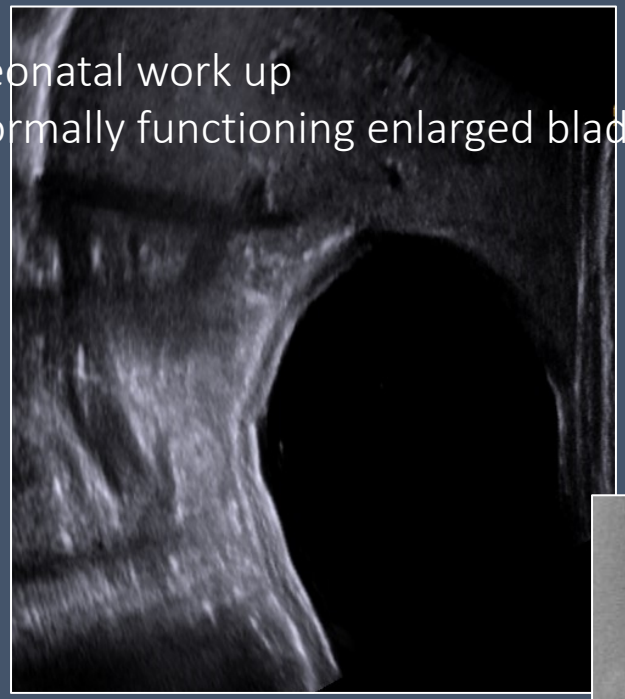


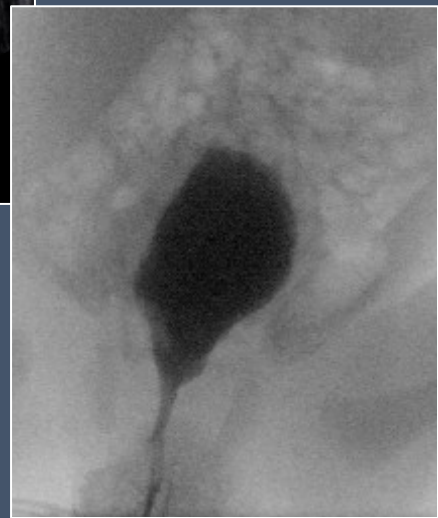






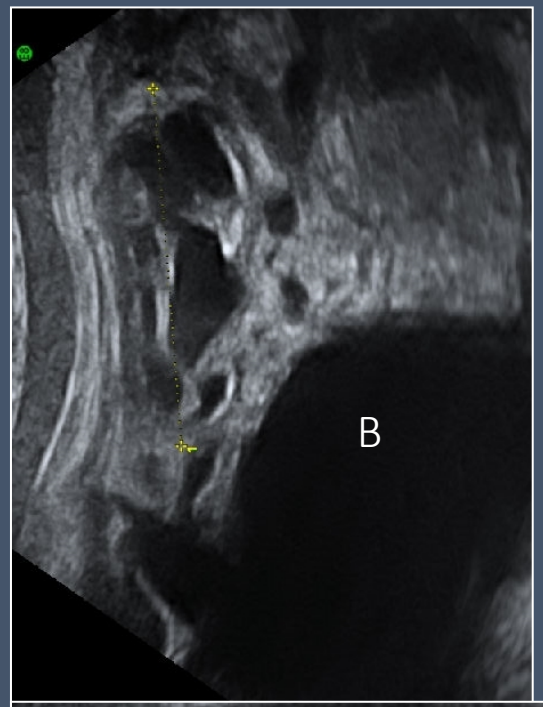
Neonatal work up
Normally functioning enlarged bladder



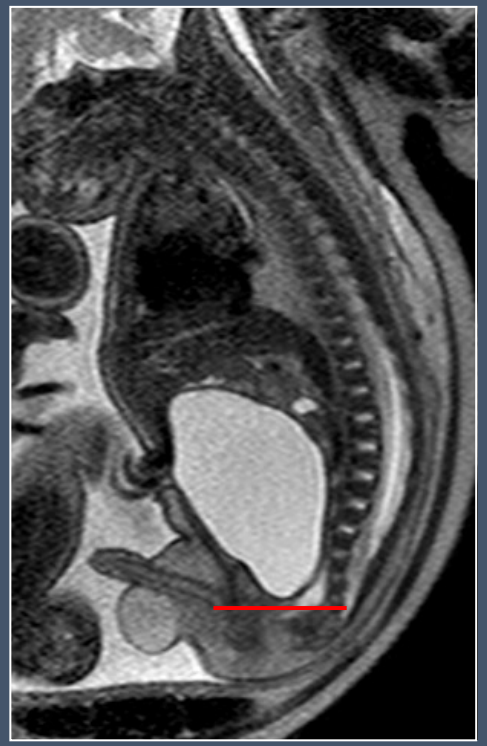


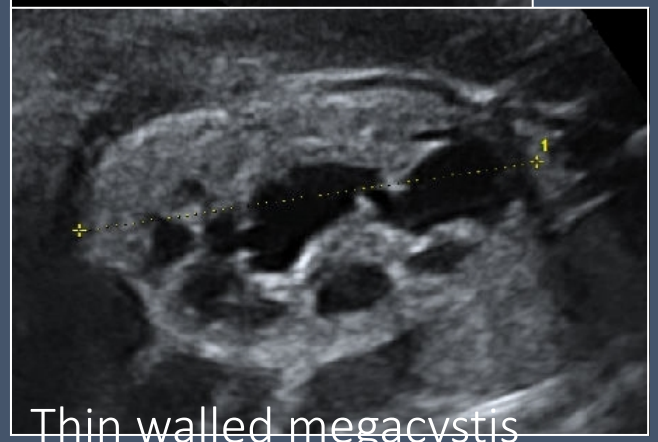
Thin walled megacystis ++
MRI to exclude MMH syndrome

Refluxing megacystis

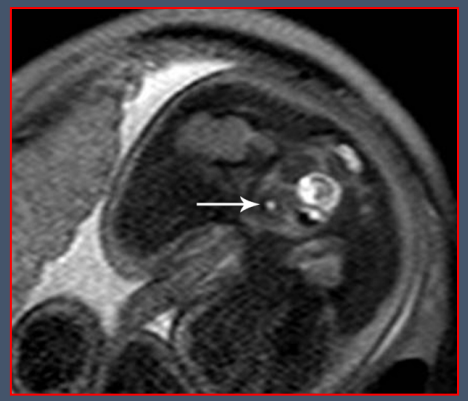


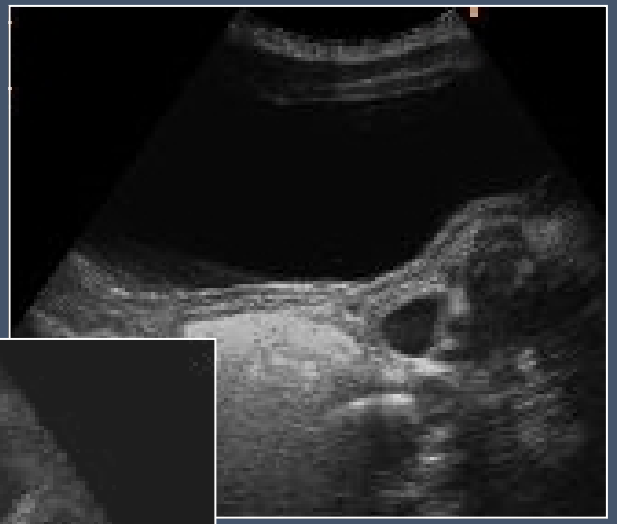
37 W
Male fetus

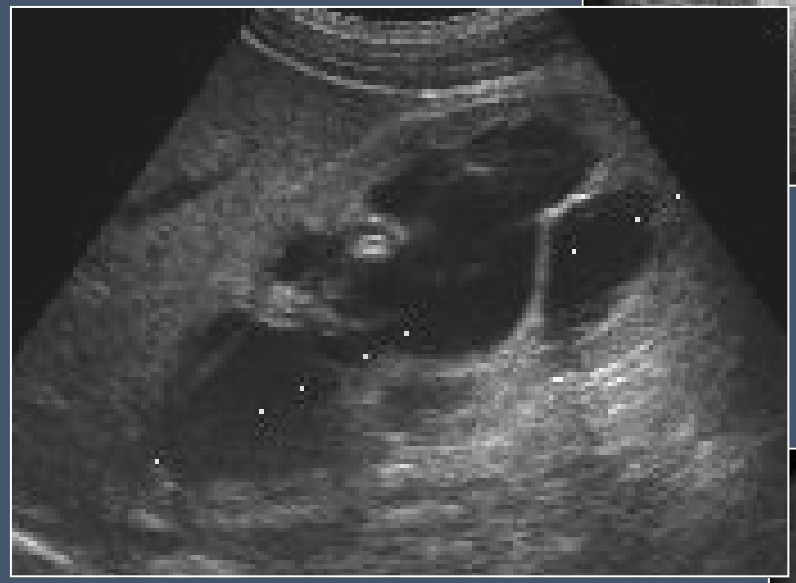




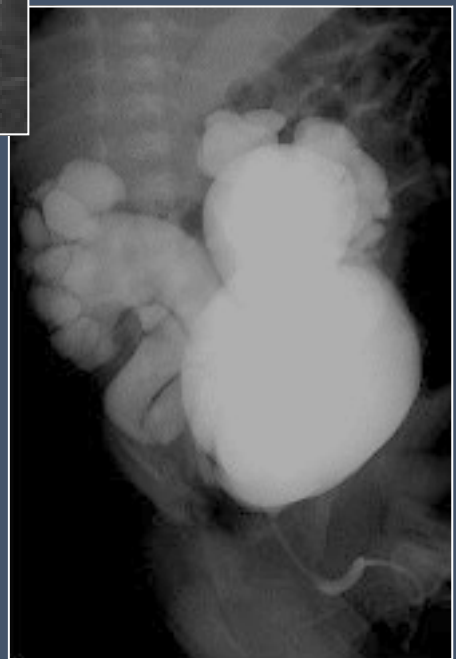
Thin walled megacystis
Bilateral renal cavities dilation
CM dedifferentiation >> PUV?







Neonatal work-up
Bilateral High grade reflux



Megacystis
Post natal work-up

- Neonatal period

  > US to confirm the diagnosis and visualize the kidneys

  > VCUG to exclude obstructive etiology and reflux (if associated US signs)

- Long term follow-up

  It should be adapted to the underlying condition responsible of the megacystis

  > ”physiological” causes will resolve spontaneoulsy (decreased hormonal level, medications…)

  > obstructive or refluxing conditions have to be treated accordingly

Urology 2014; 84:185-191

Fetal uropathies

A. Upper urinary tract dilation
   1. Obstructive uropathies
      - PUJS
      - Primary megaureter
   2. Refluxing uropathies

B. Megacystis
   - Differential diagnosis
   - PUV

C. Other malformative uropathies
   - MCKD
   - Duplex kidneys
   - Abnormal bladder > urogenital sinus
                      > bladder exstrophy

PUV

- PUV responsible of low urinary tract obstruction (in male fetuses) consists in abnormal mucosal folds located at the level of the distal end of the veru montanum

> prenatal US diagnosis

thickened bladder wall

uni-or bilateral ureteral and pelvicalyceal dilatation

dilated posterior urethra visible during voiding on perineal approach

renal dysplasia

>>> close prenatal follow-up with repeated US (every month) because renal compromise can lead to anamnios, lung hypoplasia and limb deformities

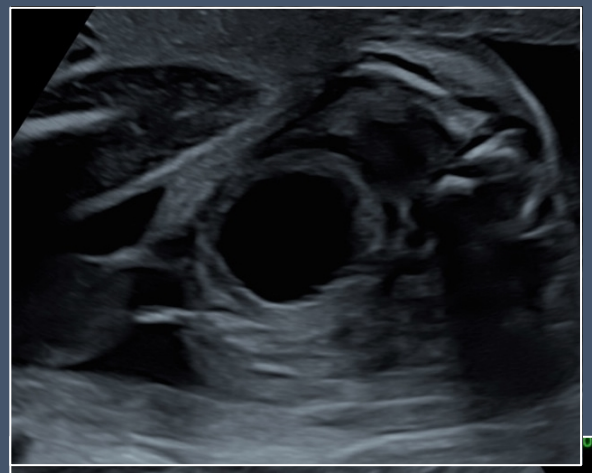
>>> in utero therapies include endoscopic valve resection or vesico-amniotic shunting (selected candidates with absence of pre-existing renal damage) leading to improved survival but no significant impact on renal function

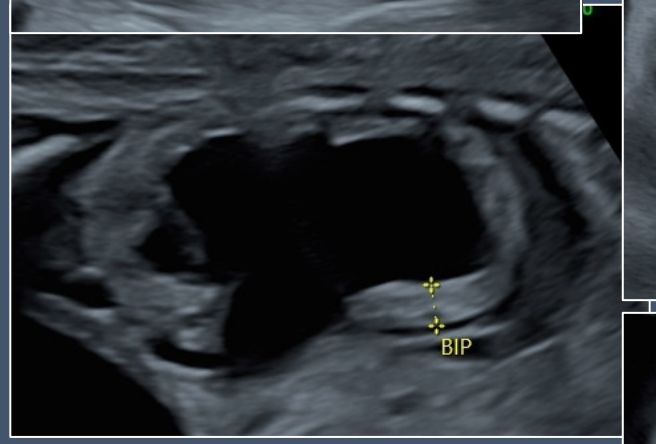
Ultrasound Obstet Gynecol 2019; 53: 520-4

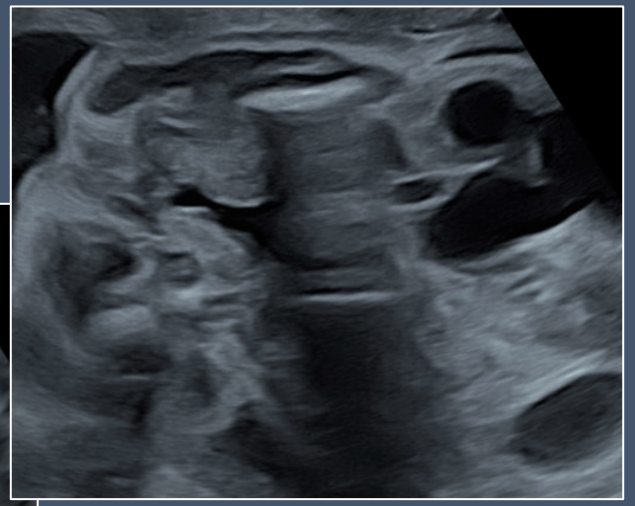
J Pediatr Urol 2017; 13:345-351

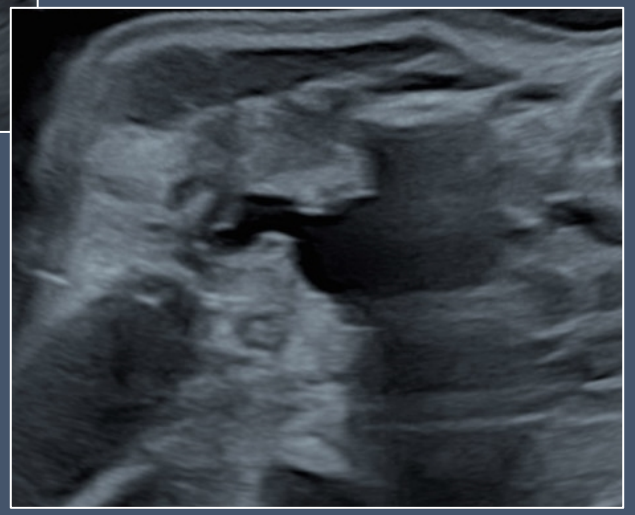
Early PUV

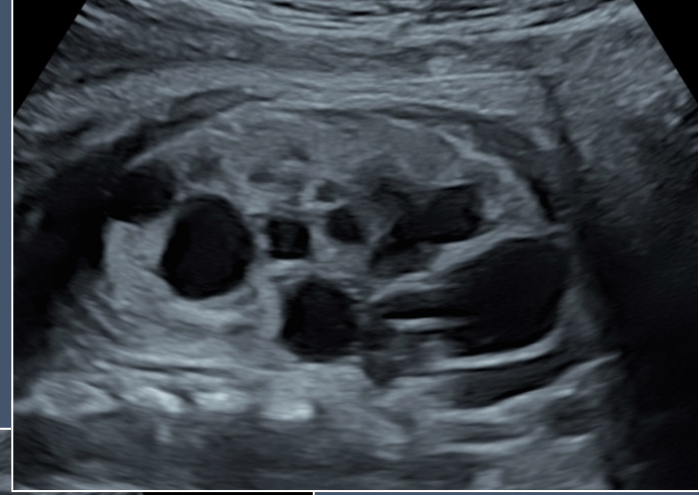
23 W Male fetus
Bilateral pyelocaliceal dilation
Thin undifferentiated renal cortex
Thickened bladder wall
Voiding dilatation of the posterior urethra

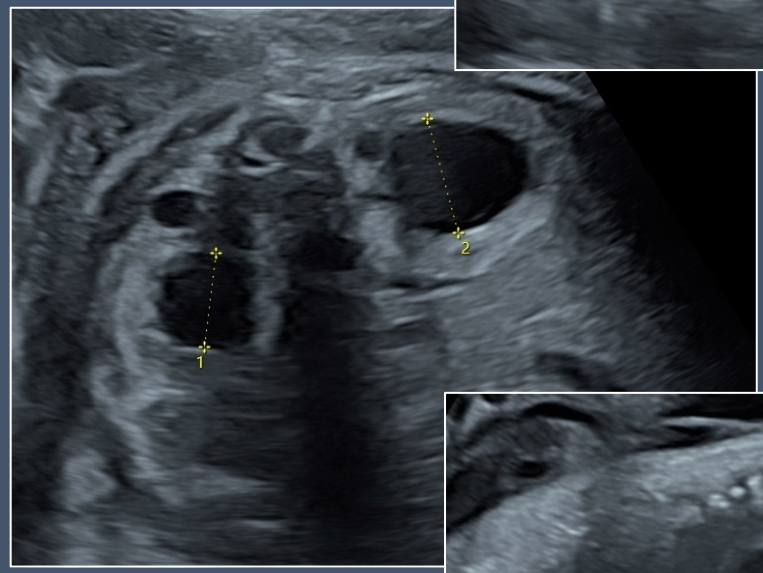


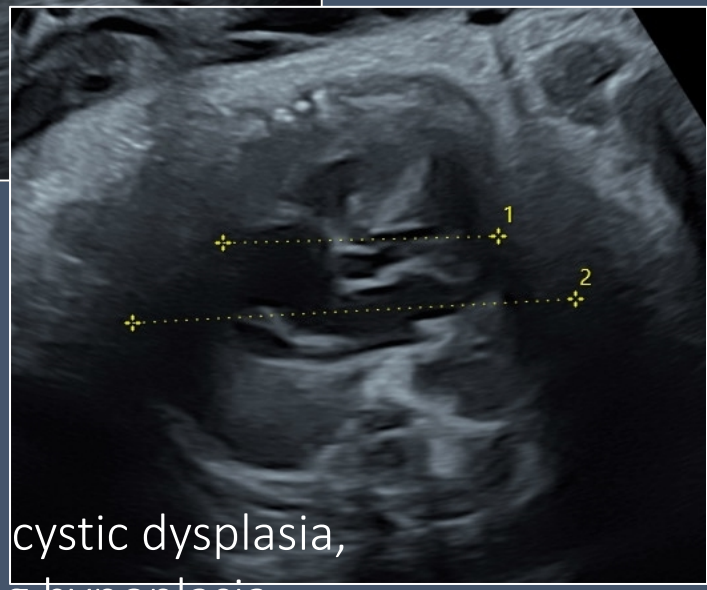






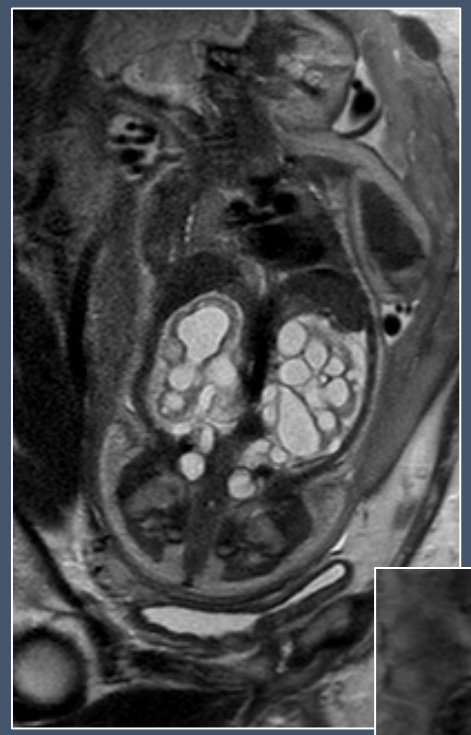




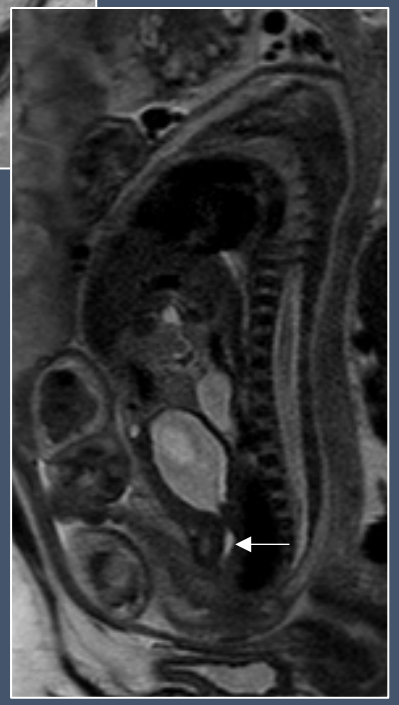


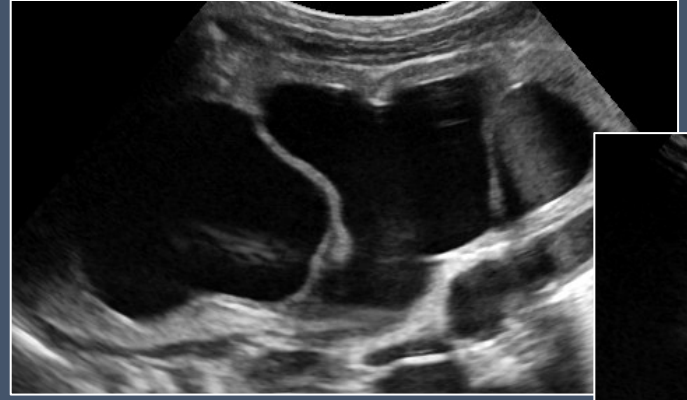
28W
Bilateral renal cystic dysplasia,
anamnios, lung hypoplasia

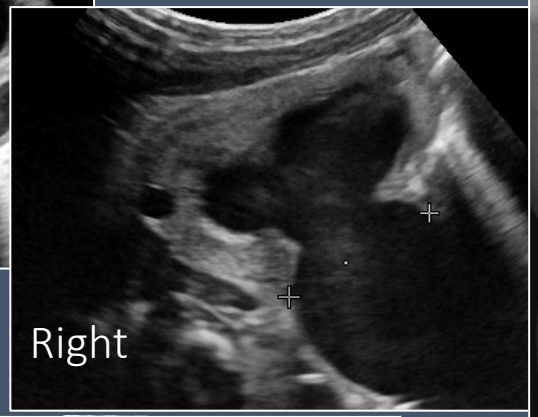
Early PUV

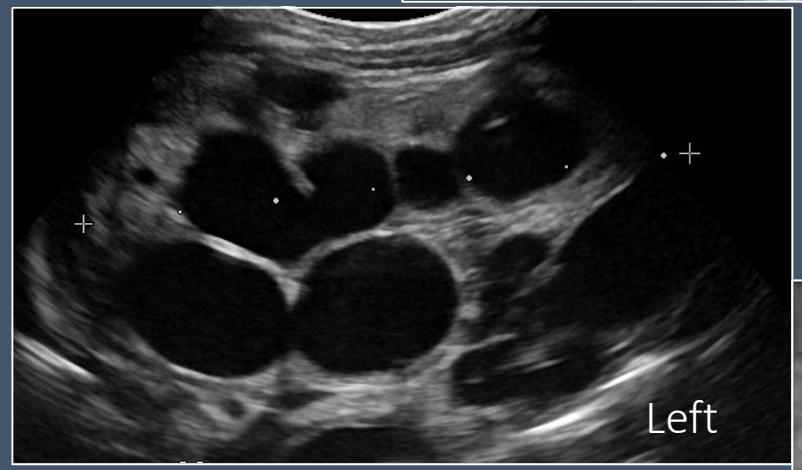


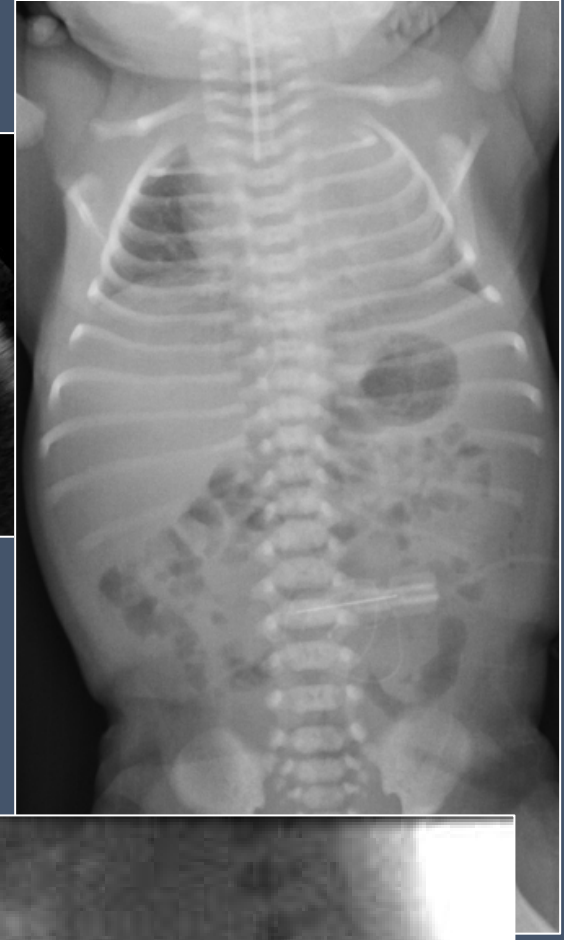
29 W

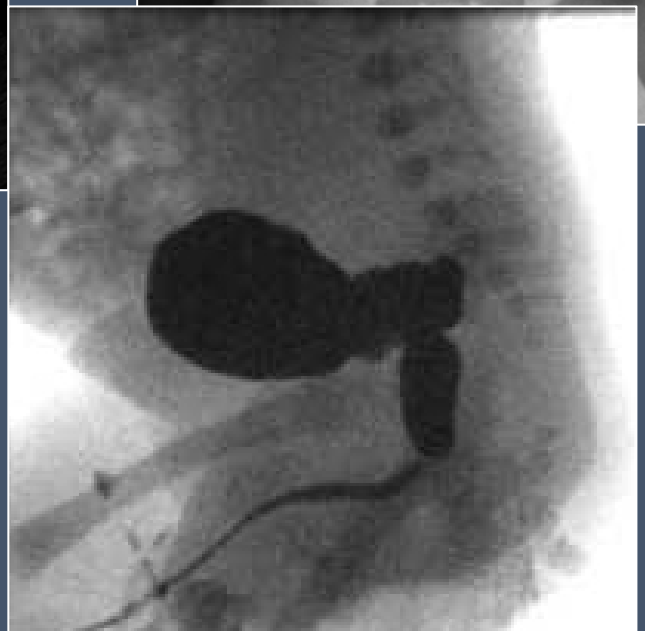












Neonatal US
Bilateral renal obstructive cystic dysplasia
Lung hypoplasia <<< anamnios
VCUG PUV confirmed - no reflux

PUV
Post natal work-up

- Neonatal period

  > Delivery in a maternity with urological expertise

  > Neonatal US, VCUG, bladder drainage, ABP and close monitoring of renal function and electrolytes serologic levels

  > Valve resection

- Long term follow-up

  Repeated US examinations

A multidisciplinary team is required

to monitor the renal function and respiratory support

to follow the urodynamic function of the bladder

to treat the recurrent infections possibly associated with the reflux

J Urol 2016; 196:862-868

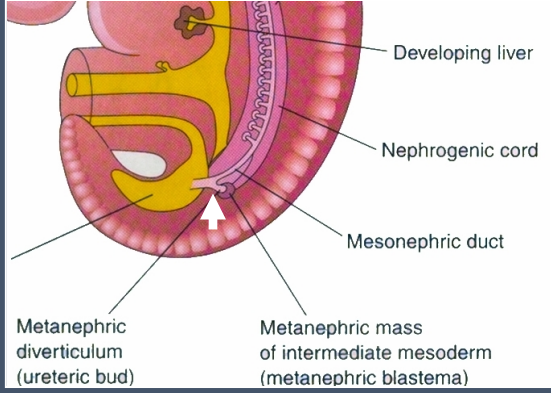
Fetal uropathies

A. Upper urinary tract dilation
   1. Obstructive uropathies
      - PUJS
      - Primary megaureter
   2. Refluxing uropathies

B. Megacystis
   - Differential diagnosis
   - PUV

C. Other malformative uropathies
   - MCKD
   - Duplex kidneys
   - Abnormal bladder > urogenital sinus
                      > bladder exstrophy

C. Malformative uropathies
MCKD



- Abnormal differentiation of the metanephros due to altered reciprocal induction by abnormal ureteric budding >> the renal parenchyma is replaced by non communicating cysts of different size – no functioning renal parenchyma > not compatible with life in bilateral cases

  > prenatal US diagnosis

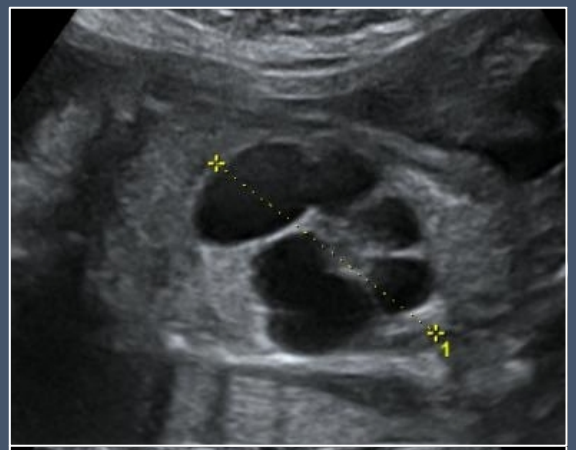
  huge macrocystic mass replacing the kidney

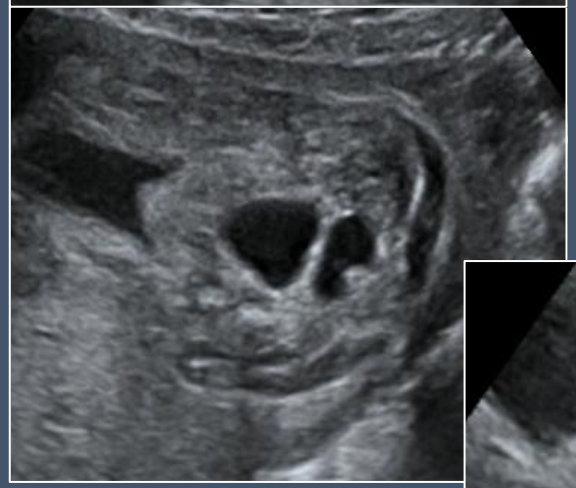
  importance of the contra lateral kidney which is considered as a solitary kidney

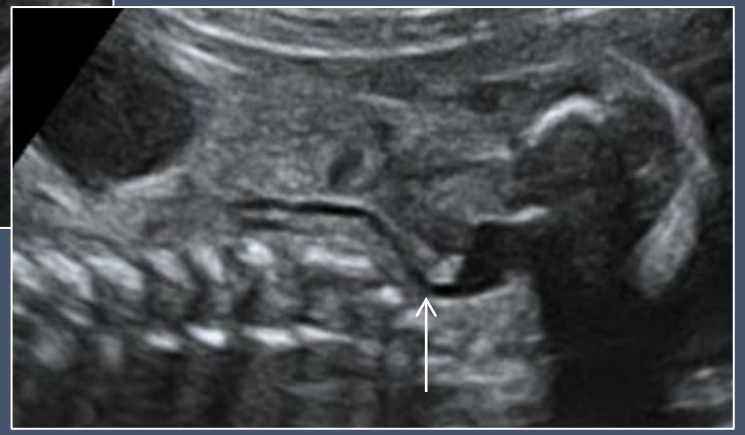
  search for ectopic ureteral insertion signs

Fetal Therapy and Diagnosis 2018; 10:1-8

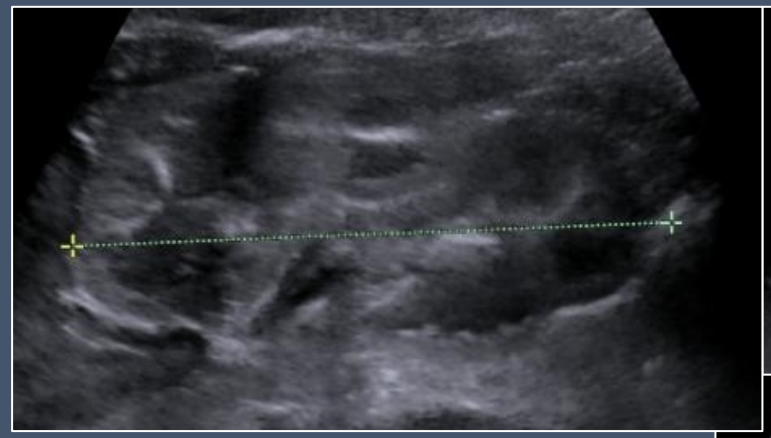
MCKD
Ectopic ureteral insertion

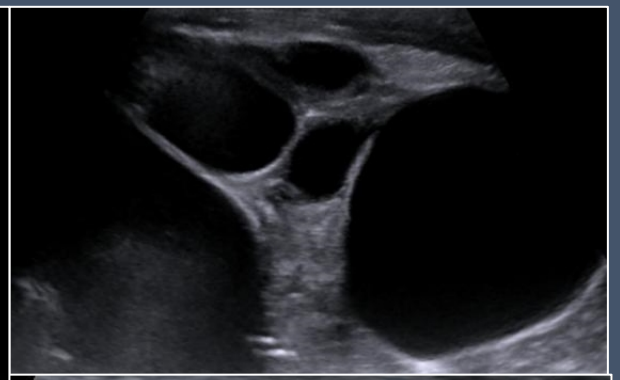




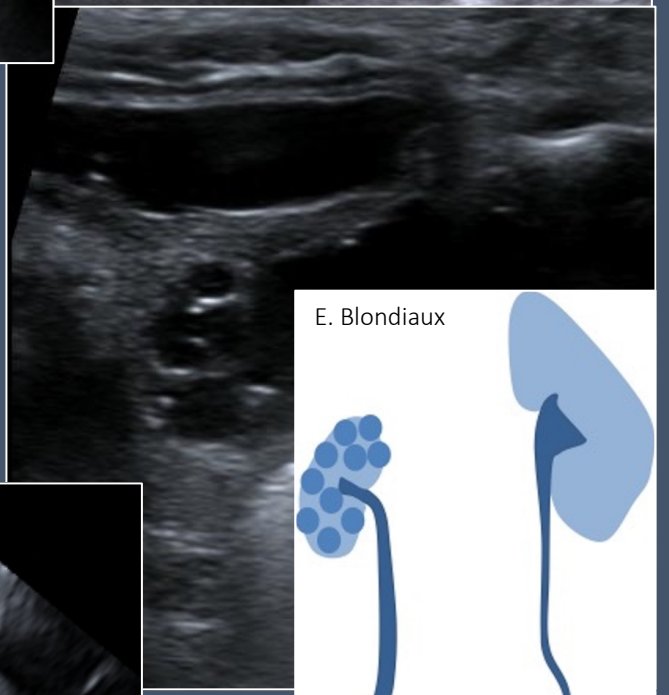


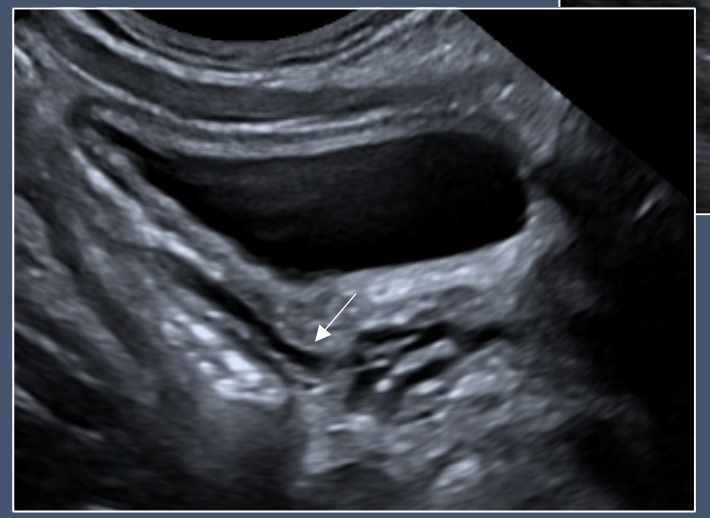
26 W Male fetus
MCKD, normal contralateral kidney
retrovesical cyst >> ectopic ureteral insertion (in the seminal vesicles?)





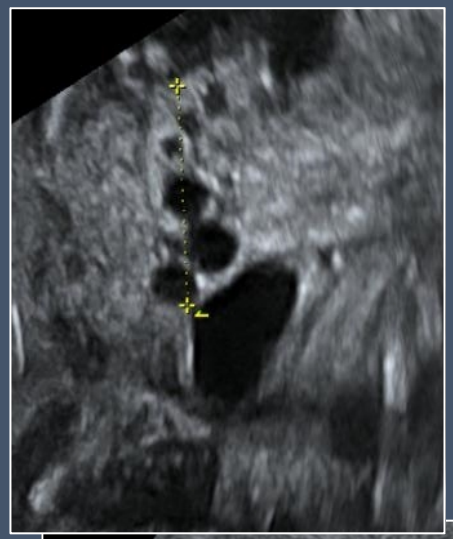
Neonatal US



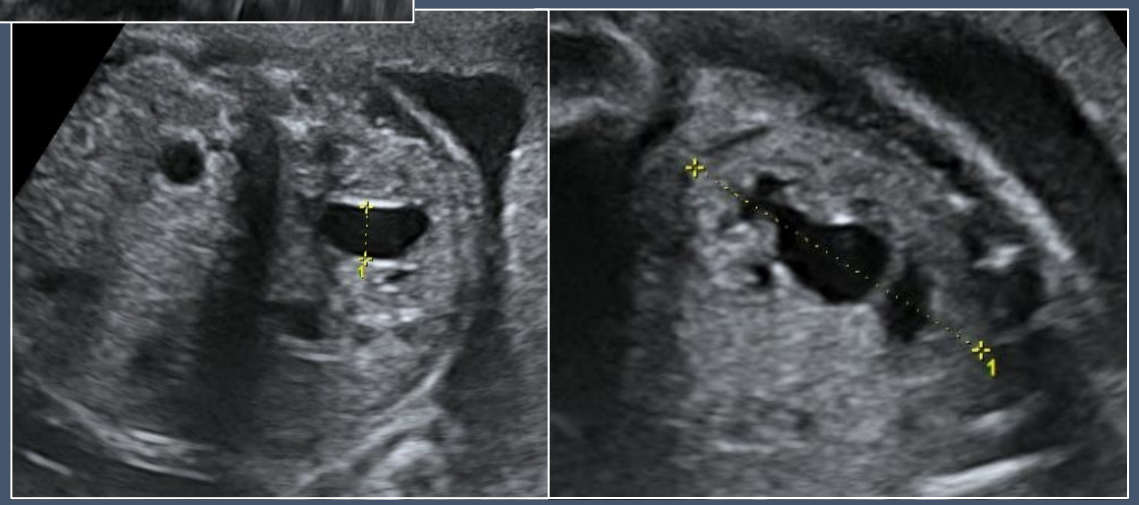


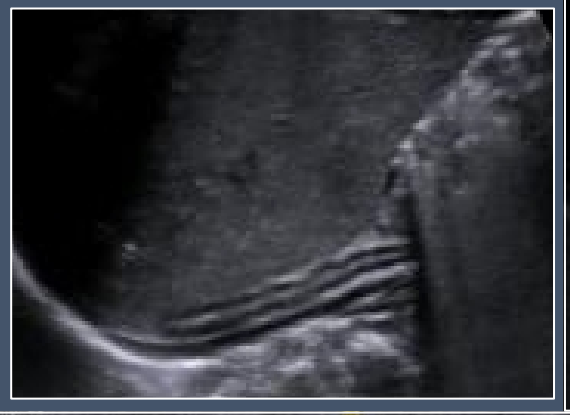
Zinner syndrome

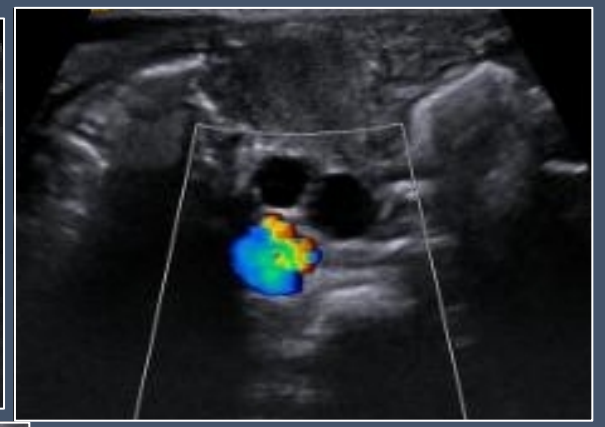
Ectopic MCKD
Contralateral reflux
Duplicated Mullerian structures

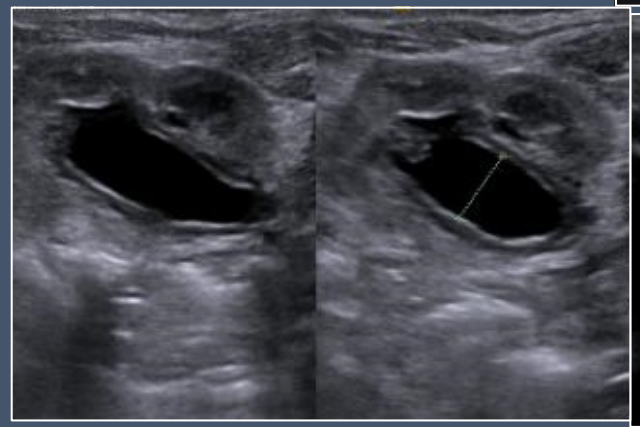


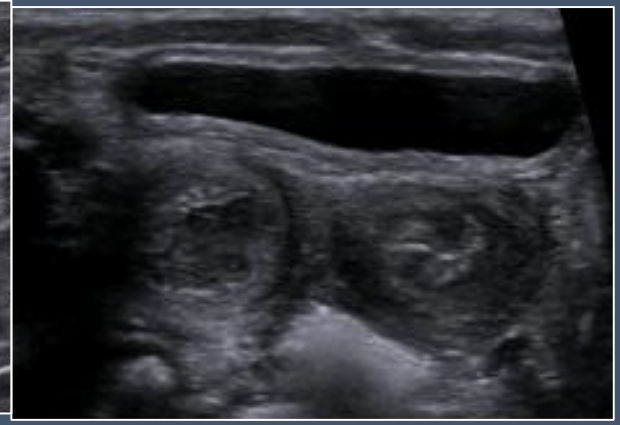
27 W Female fetus
Right pelvic MCDK
Left pyelic dilation



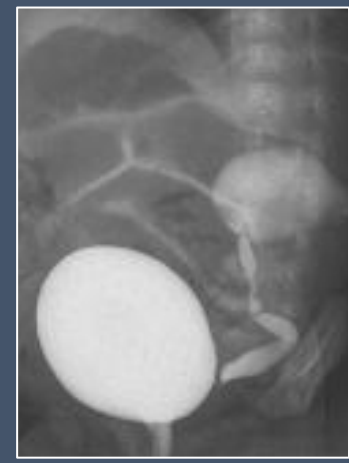








Post natal work up
Right pelvic MCDK – Associated duplicated uterus
Left renal pyelic dilatation with thickened wall
>> VCUG confirming the VUR



MCKD
Post natal work-up

- Neonatal period

  US

  > to confirm the diagnosis

  > check the contra lateral kidney that has to be considered as a solitary kidney

  > search for pelvic cystic lesions (EUI)

  > duplicated genital tract

- Long term follow-up

- In case of normal contralateral kidney, annual US to check the kidney growth (solitary kidney) and involution of MCK

- In case of contralateral renal anomaly, adapt the follow-up accordingly

Journal of Pediatric Urology 2014; 10, 645-649

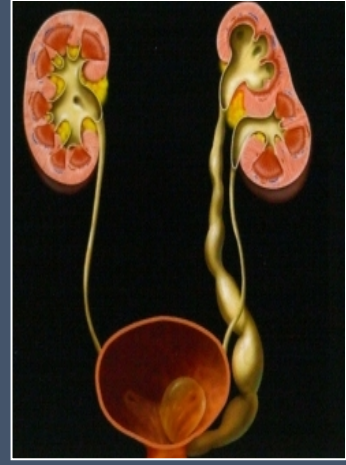
Fetal uropathies

A. Upper urinary tract dilation
   1. Obstructive uropathies
      - PUJS
      - Primary megaureter
   2. Refluxing uropathies

B. Megacystis
   - Differential diagnosis
   - PUV

C. Other malformative uropathies
   - MCKD
   - Duplex kidneys
   - Abnormal bladder > urogenital sinus
                      > bladder exstrophy

Duplicated collecting system



- Two ureteric buds arise from the mesonephric duct

leading to a renal collecting system split into two separated moieties drained by two ureters

Dilation may result from ***obstruction*** (ectopic ureteral insertion - upper pole, uretral prolapsus of the ureterocele) or from ***reflux*** (normotopic insertion- lower pole)

> prenatal US diagnosis

two pelvic hilar cavities separated by a parenchymal bridge

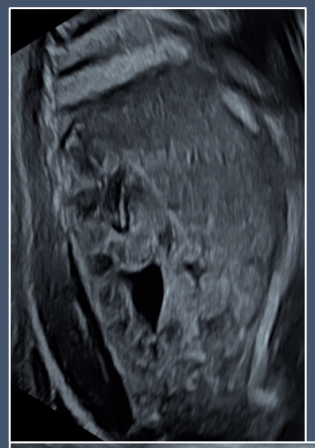
dilation may concern the upper or lower pole or both

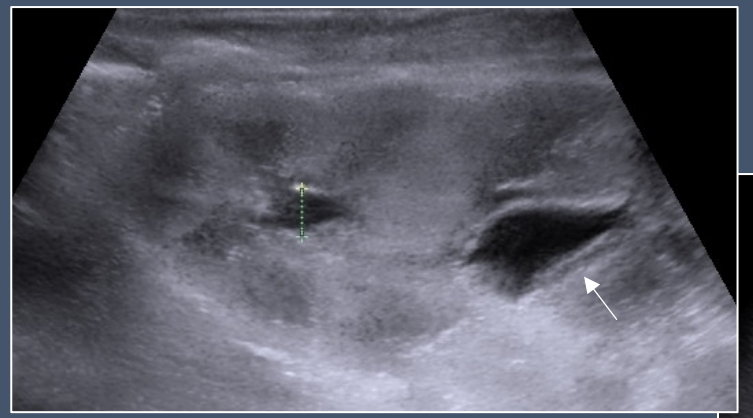
search for signs of obstruction or reflux

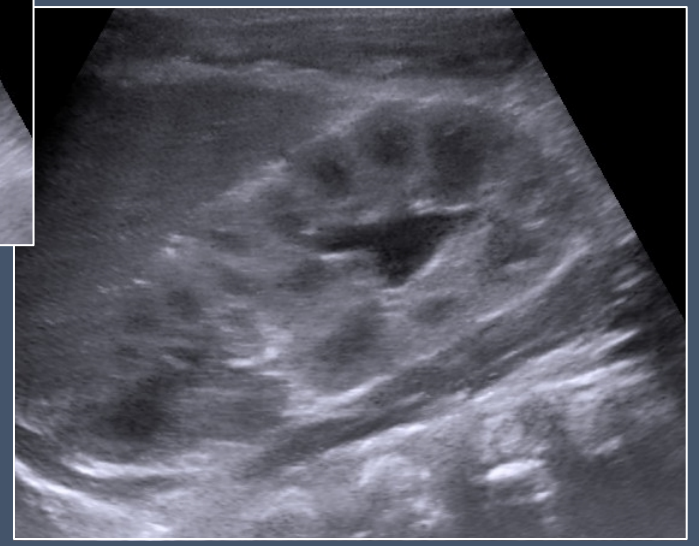
search for ureterocele

Taiwan J Obstet Gynecol 2019; 58(4):531-5

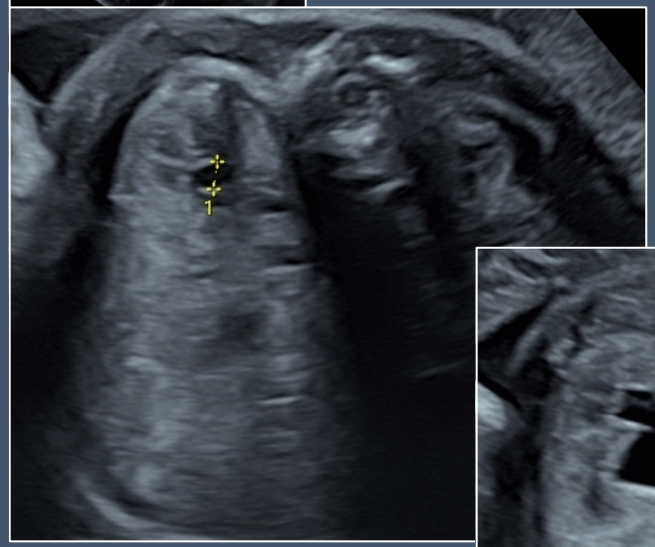
Duplex kidney
Lower pole reflux

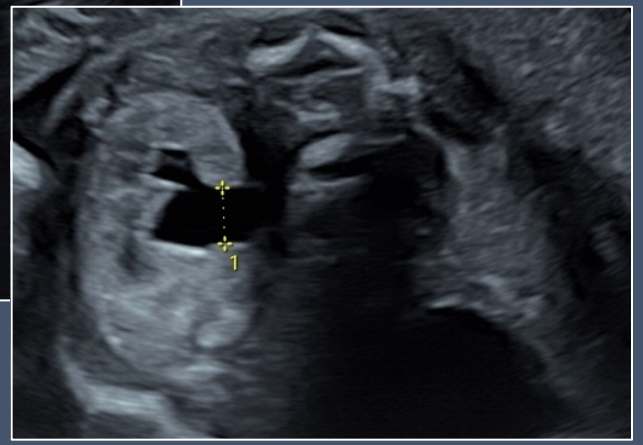




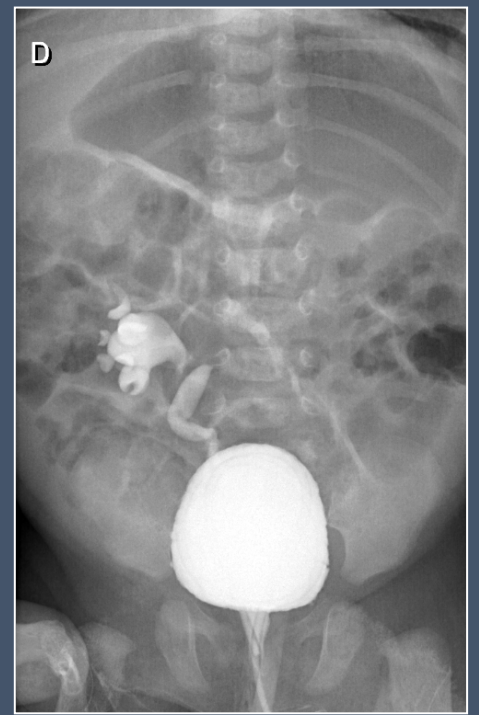


33 W Female fetus
Duplicated kidney with fluctuating dilation
of the lower pole pelvic cavity: suggesting reflux

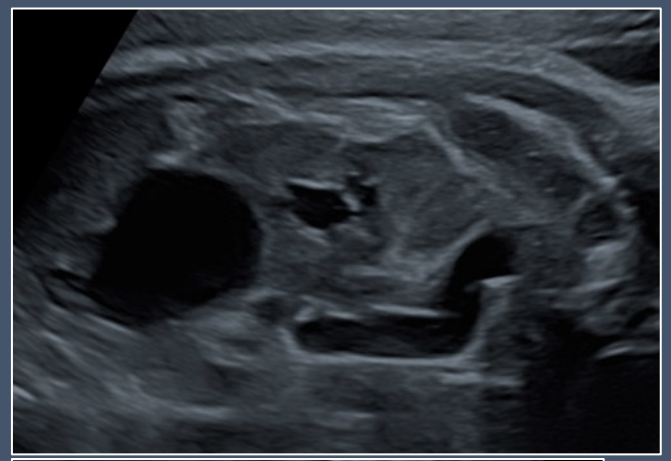


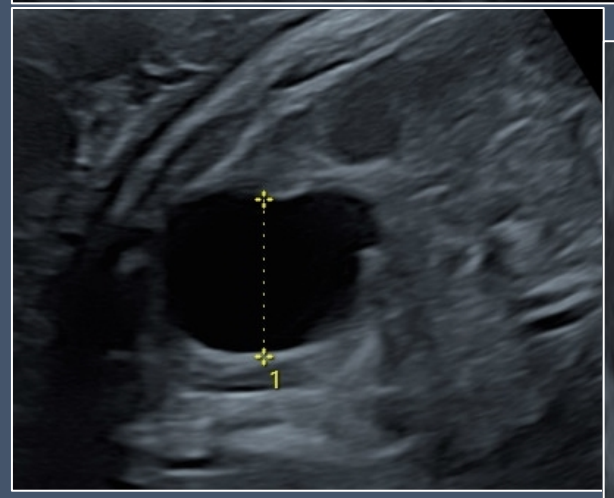


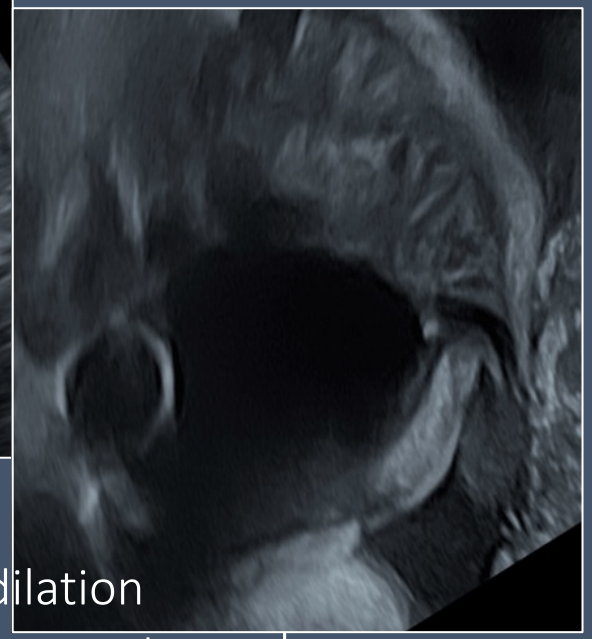
Post natal work up
Confirming the duplication
and lower pole reflux



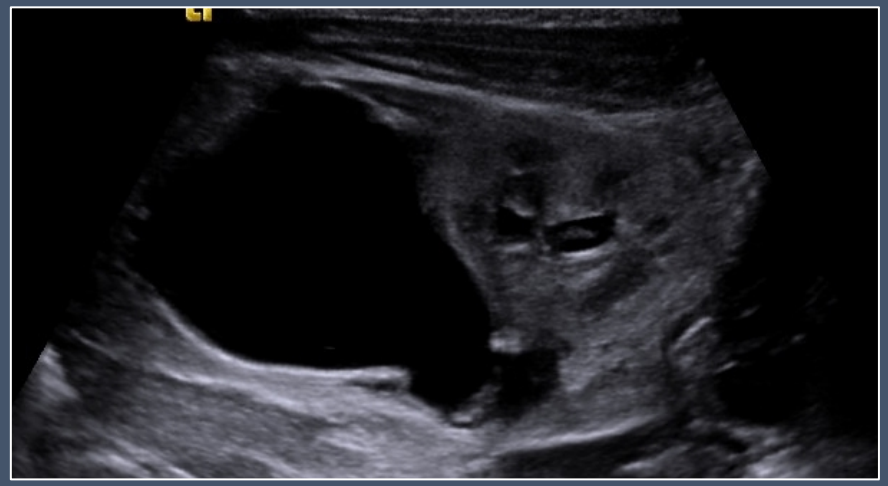
Duplex kidney
Obstructive upper pole- ureterocele



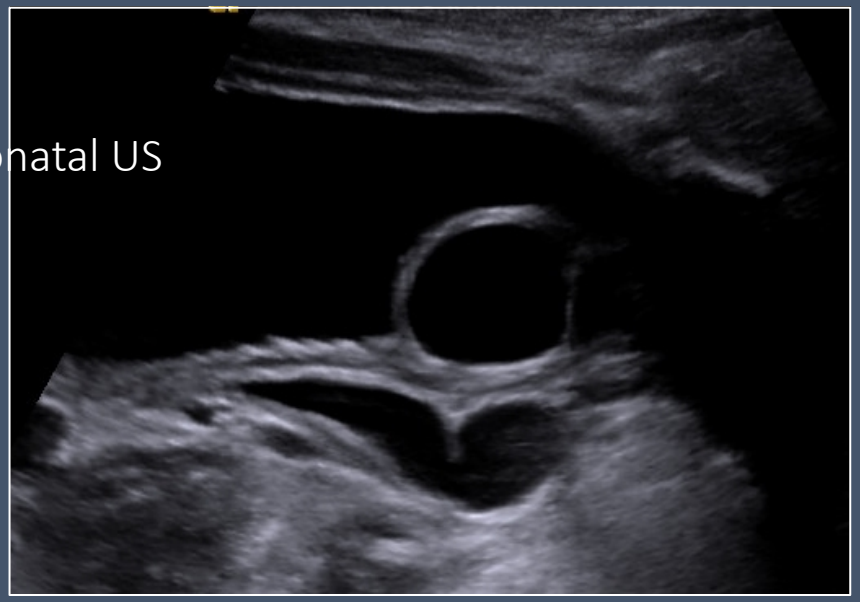




34 W
Duplicated left kidney with dilation of the upper pole, megaureter, ureterocele

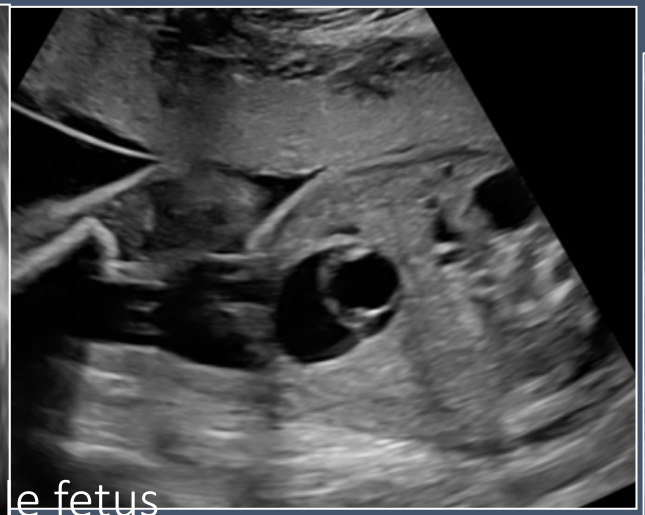


Neonatal US

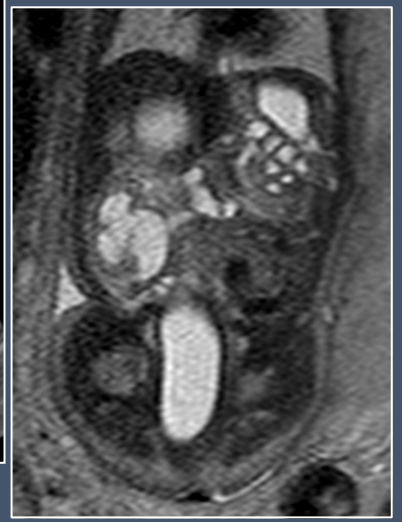


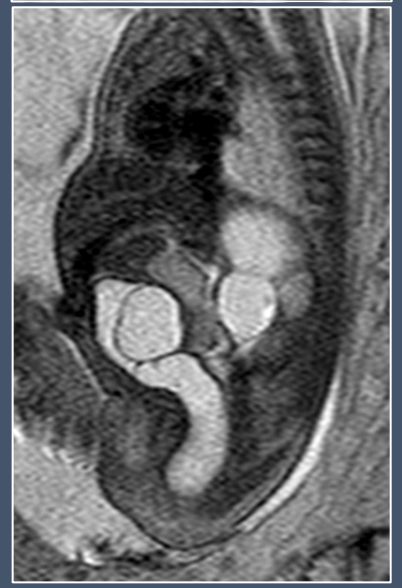
Dilation of the upper pole drained by a megaureter inserted with a ureterocele in the bladder

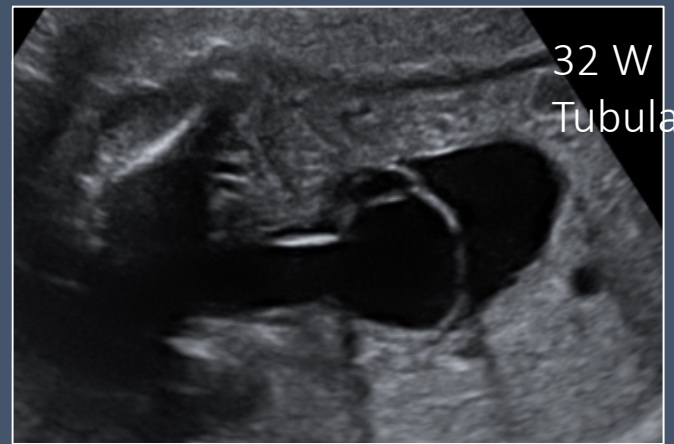
Duplex kidney
MCD upper pole - caecoureterocele



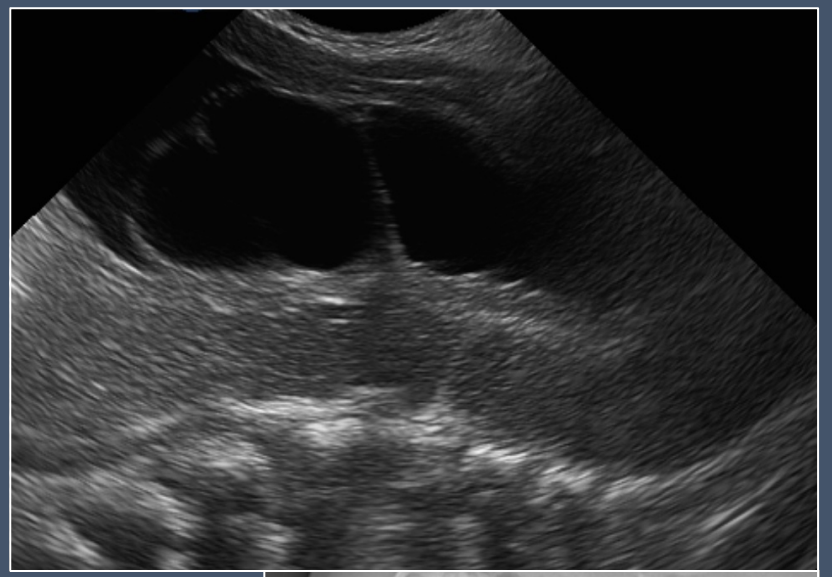
24 W Female fetus
Duplicated right kidney with
dysplastic upper pole and ureterocele



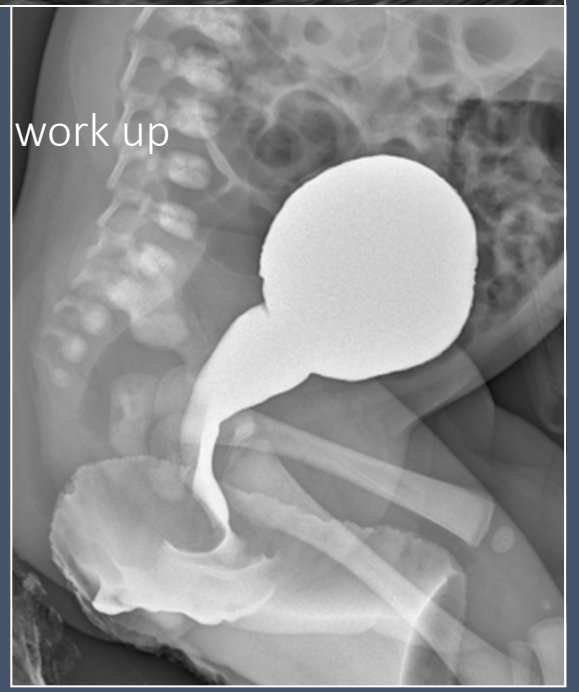




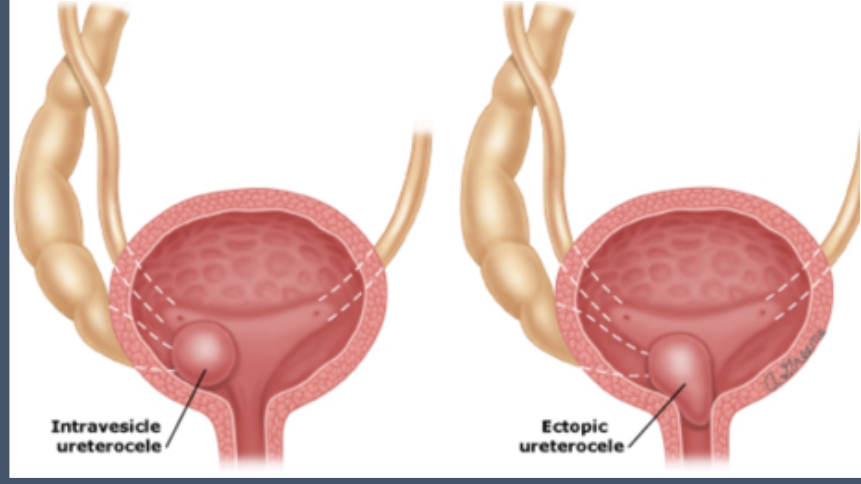
32 W
Tubular pelvic structure



Post natal work up



Duplex kidneys
Post natal work-up



- <u>Neonatal period</u>

  US

  > to confirm the duplex system

  > to search for an ureterocele possibly overlooked prenatally

  > to assess the renal parenchymal aspect in dilated poles

- <u>Long term follow-up</u>

  - US follow-up according to the renal aspect
  - VCUG to search for reflux and prolapsing ureterocele
  - Isotopic data in case of upper pole atrophy
  - MRI may help to locate ectopic ureteral insertions

>>> surgical treatment is recommended to treat obstructive ureterocele and heminephrectomy in case of absent renal function

J Pediatr Surg 2018; 53(4):813-7
Taiwan J Obstet Gynecol 2019; 58(4):531-5

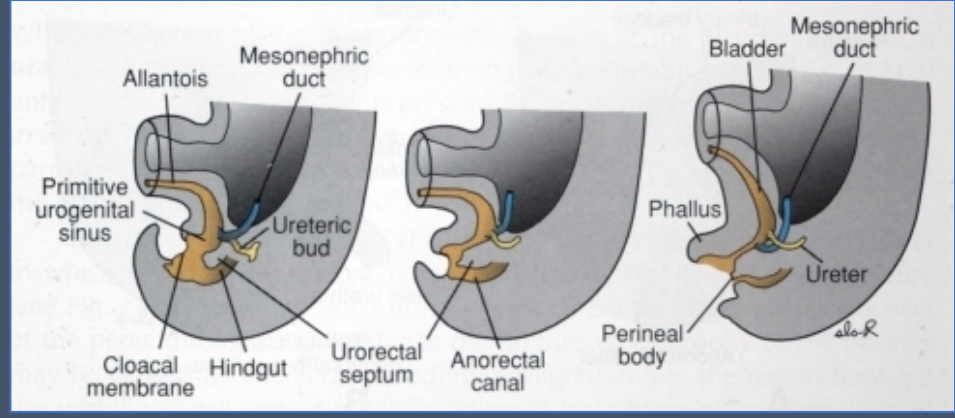
Fetal uropathies

A. Upper urinary tract dilation
   1. Obstructive uropathies
      - PUJS
      - Primary megaureter
   2. Refluxing uropathies

B. Megacystis
   - Differential diagnosis
   - PUV

C. Other malformative uropathies
   - MCKD
   - Duplex kidneys
   - Abnormal bladder > urogenital sinus
     > bladder exstrophy

Uro genital sinus



- Spectrum of abnormal partitioning between the urinary and the genital tract. The uro-genital sinus is a variant with the bladder and genital tract sharing a single orifice

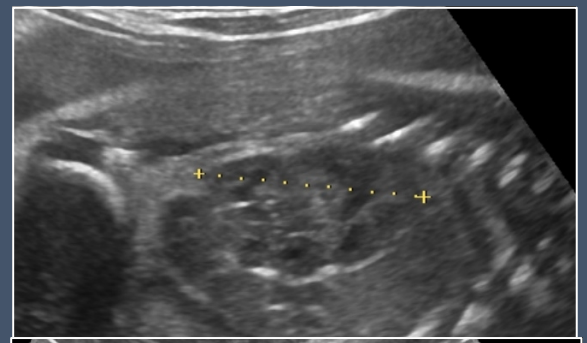
  > Prenatal diagnosis

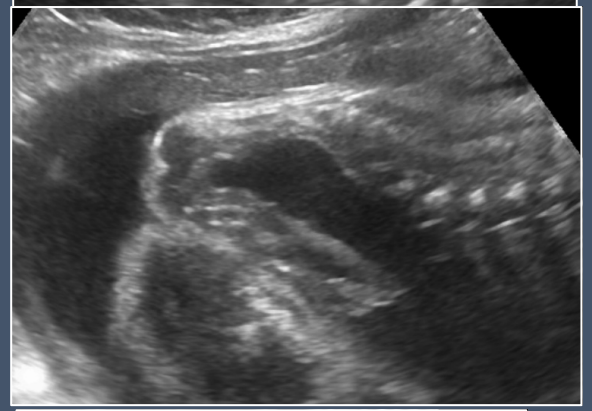
  Mostly relies on the discovery of a cystic retrovesical lesion in a female fetus

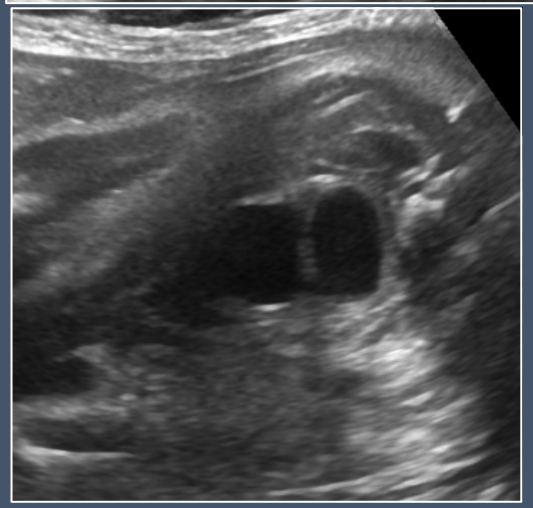
  >>> MRI may help in depicting the communications between the different systems: urinary and digestive tracts

Eur J of Radiol 2010;76: 256-254

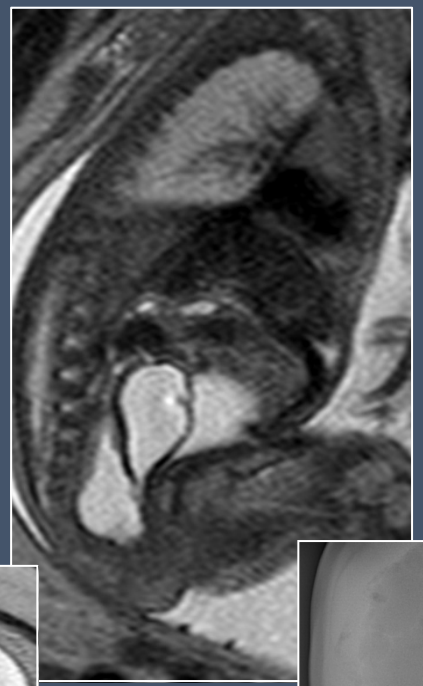
Complex uro genital sinus

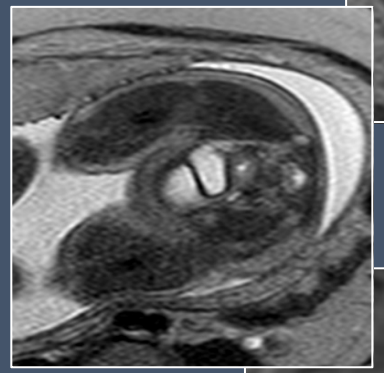


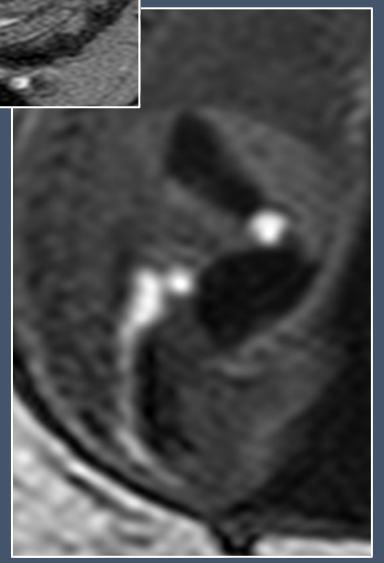


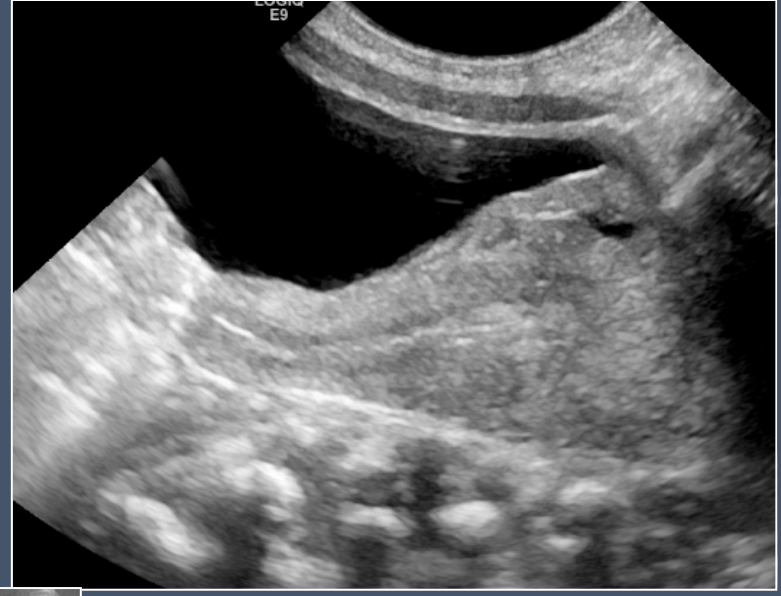


30 W
Female fetus

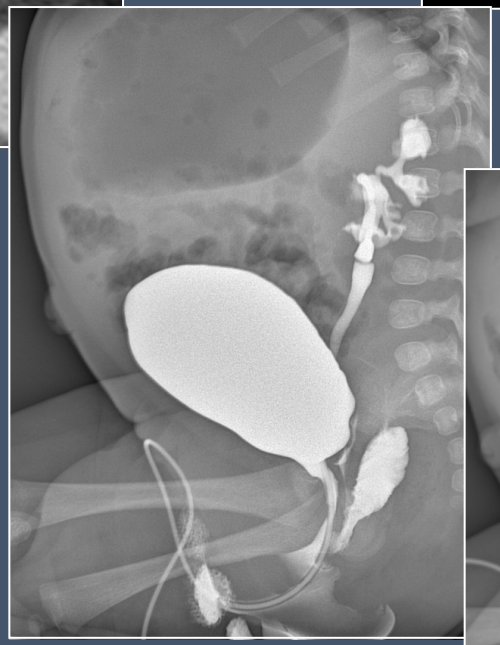




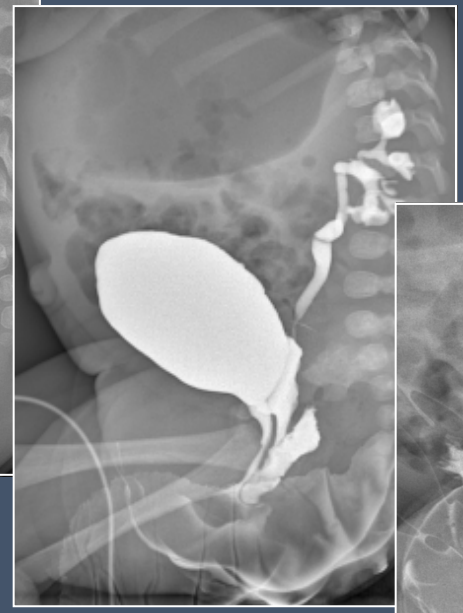


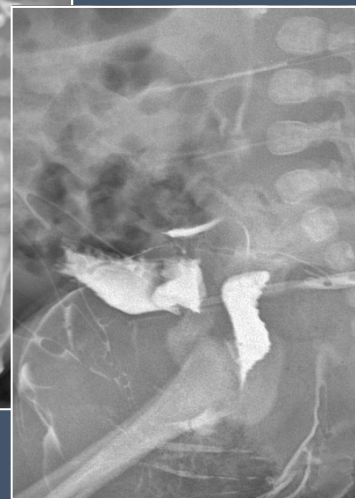


Post natal work up



Duplicated bladder
Urethro-vaginal fistula
Unilateral reflux





Uro genital sinus
Post natal work-up

- Neonatal period

  Clinical investigations of the perineum

  US > to check the upper urinary tract

  > perineal and pelvic anatomy

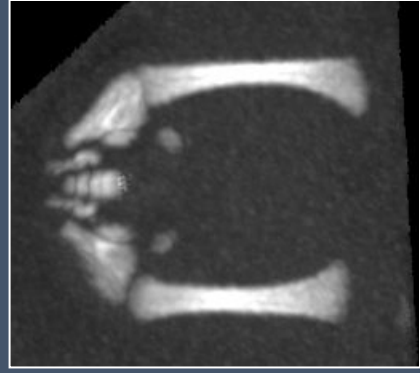
  MRI and opacification to clarify the anatomy and the communications between the genital and urinary tracts

  ABP

  Surgery

Ped Radiol 2017; 47: 1369-1380

Bladder exstrophy

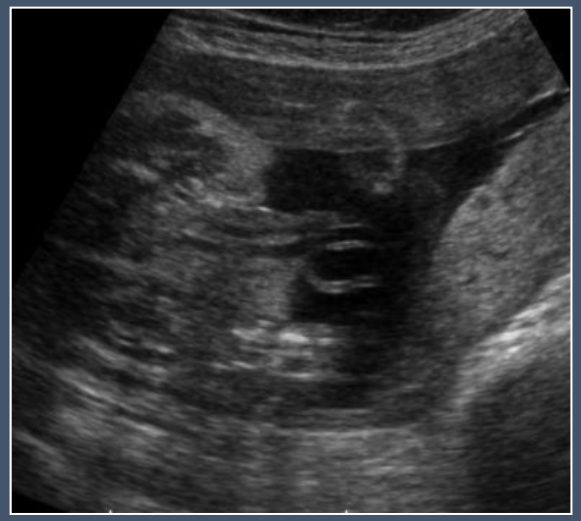


- It results from a failure in the development of muscle and connective tissue in the anterior abdominal wall and absence of anterior bladder closure with fetal urine directly excreted into the amniotic fluid
  - > prenatal US diagnosis
    - non visualisation of the bladder
    - low umbilical cord insertion
    - parallel umbilical arteries
    - spaced pubic bones
    - EGO anomalies (micropenis, epispadias)
    - kidneys and AF are N

OEIS complex including (omphalocele, exstrophy, anal imperforation, spinal anomalies)

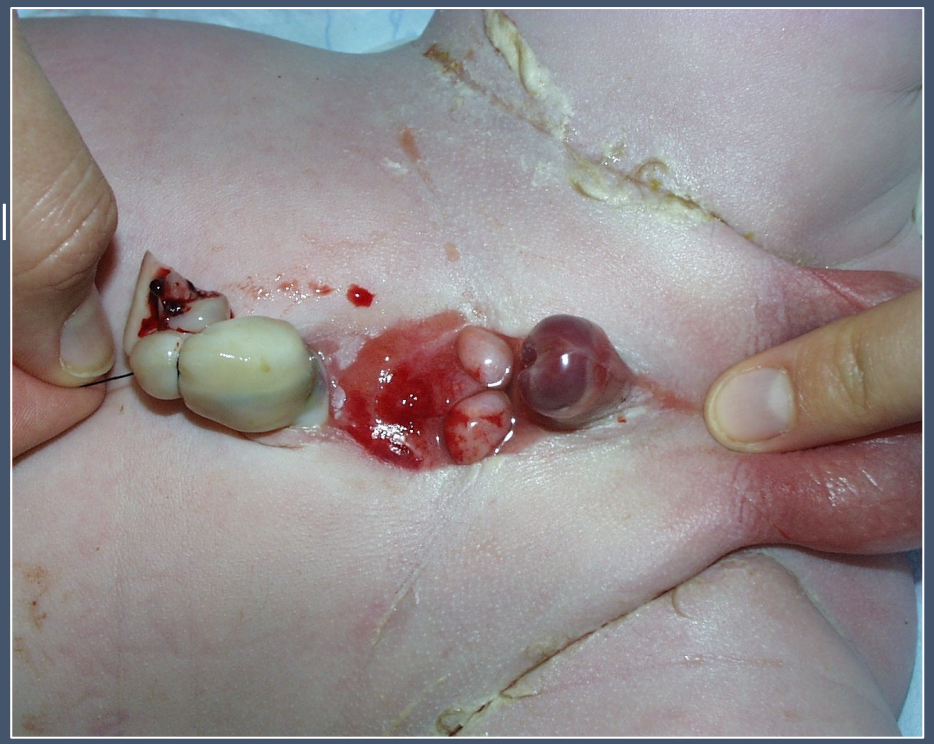
Pediatr Radiol 2013;43:593-604

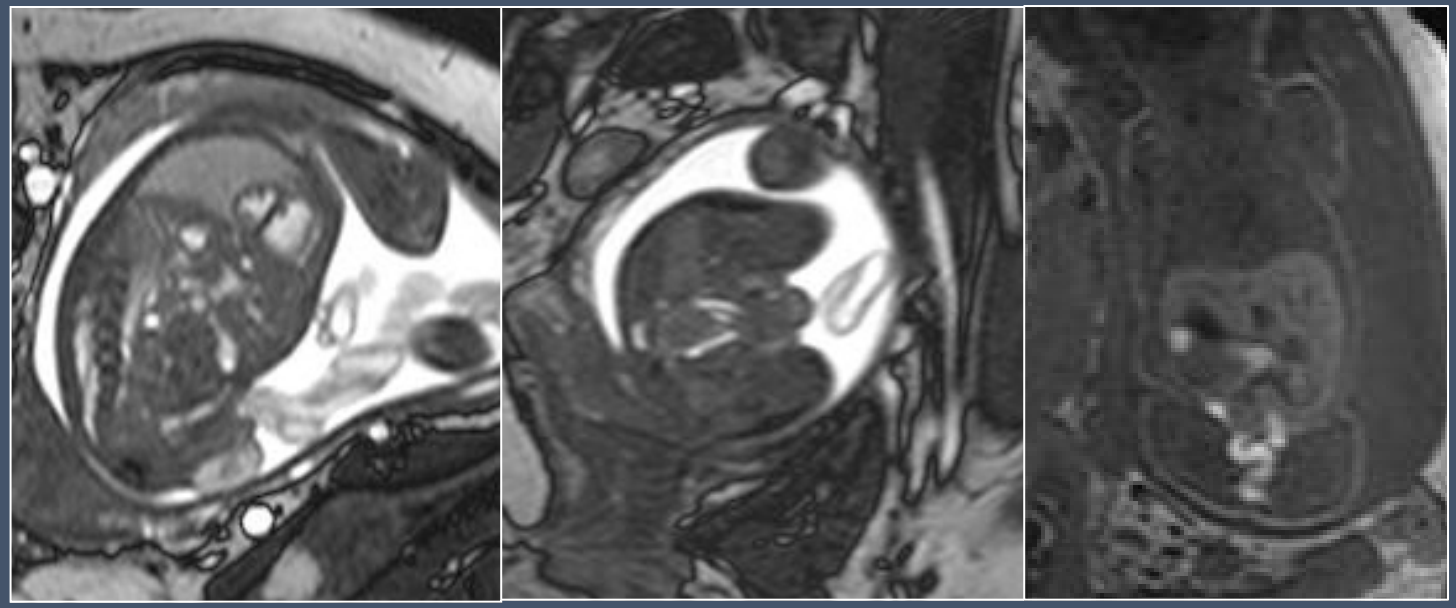
Bladder exstrophy



non visualisation of the bladder and parallel umbilical arteries
low umbilical cord insertion
EGO anomalies (micropenis, epispadias)
kidneys and AF are N

32 W Male fetus





Bladder exstrophy
Post natal work-up

- Neonatal period

  Mostly clinical investigations

  US > to check the upper urinary tract

  X ray of the spine (OEIS)

  MRI of the pelvis in complex cases

  Urgent surgery to close the bladder and reconstruct abdominal wall

  ABP

- Long term follow-up

- reconstruction of the genital organs is delayed to allow penile growth

- follow-up of frequent bladder dysfunction and sexual troubles

Prenat Diagn 2001;21:977-983

Conclusions

- Prenatal diagnosis of CAKUT is important

  - to optimize prenatal counselling and pregnancy management

  - to select the fetuses that will require urgent neonatal medical or surgical cares (PUV, severely dilated uropathies)

  - to limit the post-natal work up to investigations that should confirm the prenatal suspicion and adapt the follow-up according to the definite diagnosis

- This management requests a multidisciplinary approach and good communication between the pre and post-natal staffs