

FETAL KIDNEY ASSESSMENT

22ND ANNUAL OBSTETRICAL ULTRASOUND
SETTING THE STANDARD FOR 2019



KALESHA HACK, MD, FRCPC

RADIOLOGIST, SUNNYBROOK HEALTH SCIENCES
UNIVERSITY OF TORONTO

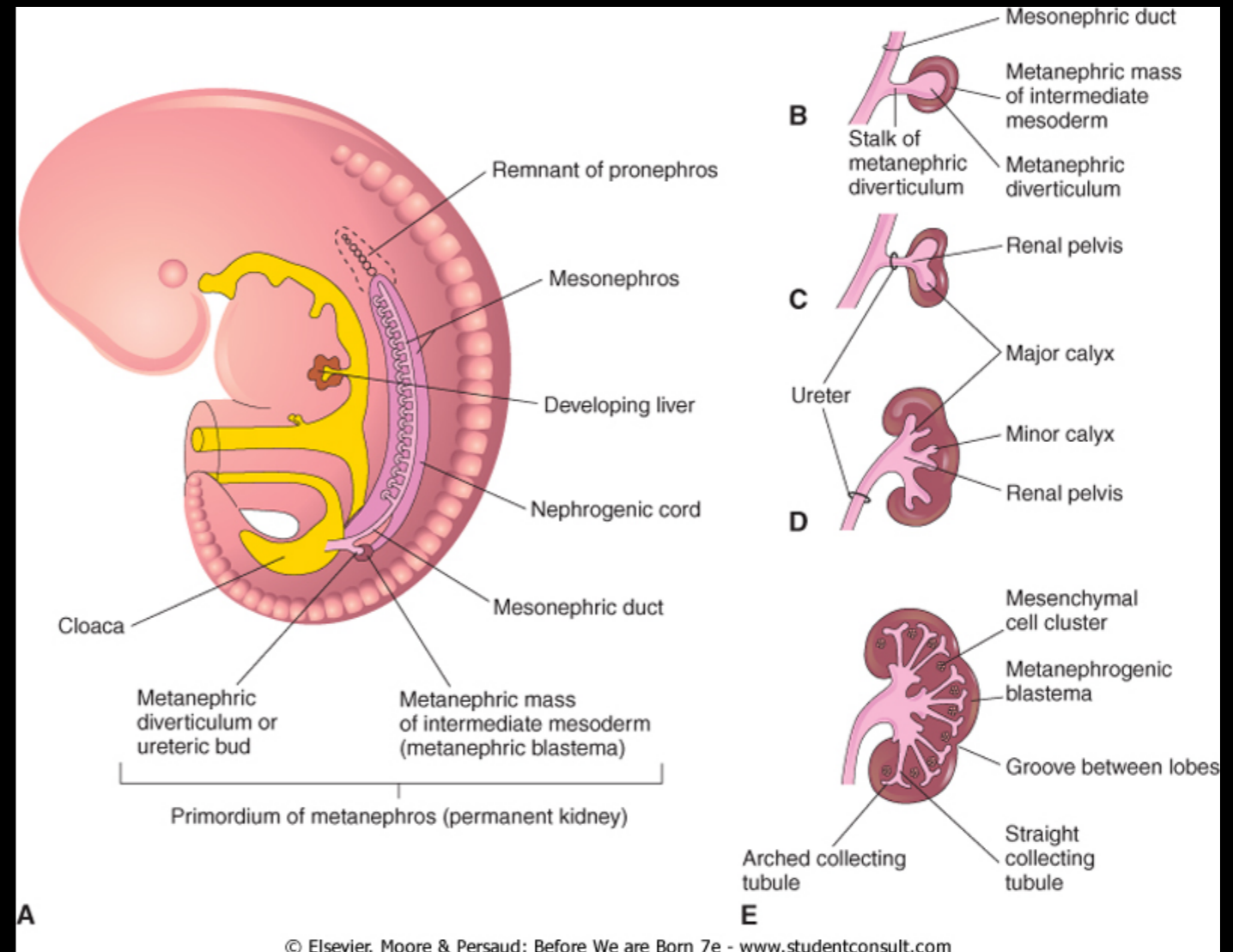
OBJECTIVES

- Normal development
- Approach to Fetal GU system
- Renal Agenesis and Ectopia
- Cystic Renal Diseases
- Echogenic Kidneys
- Urinary Tract Dilatation
- Renal Tumors

NORMAL DEVELOPMENT FETAL KIDNEYS

DEVELOPMENT OF FETAL KIDNEY

- 3 sets of fetal kidneys:
 - Pronephros
 - Mesonephros
 - Metanephros (permanent)
- 2 key structures are ureteric bud and metanephric mass
- Develops in pelvis and ascends to normal position by 11th week

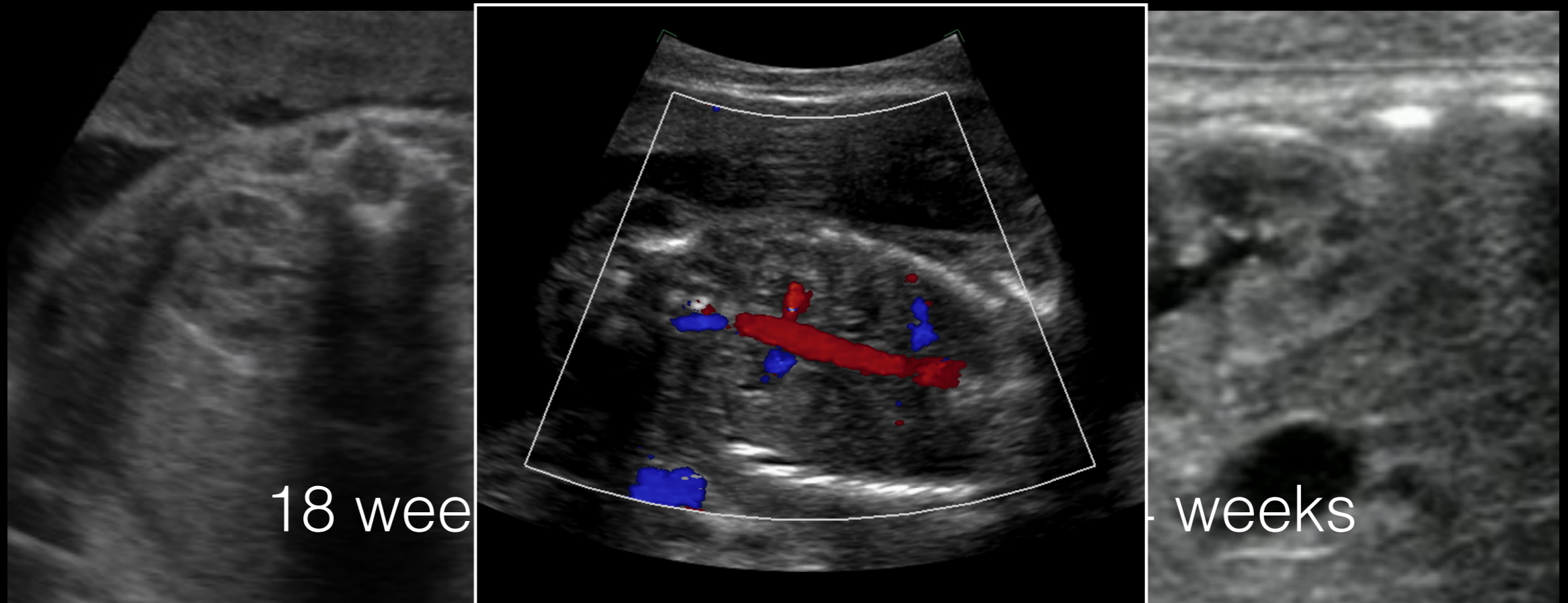


EARLY APPEARANCE FETAL KIDNEYS

- Kidneys visible 99% fetuses by 12-13 weeks
- Early sonographic appearance:
 - Oval hyperechoic paravertebral masses
 - Echogenicity similar to liver or spine
 - Corticomedullary differentiation (CMD) by 14-15 weeks
 - Reference charts for size
 - Consistent renal/abdominal circumference ratio 0.27-0.3

SECOND TRIMESTER APPEARANCE

- More isoechoic (less echogenic than liver/spleen)
- CMD should always be seen > 18 weeks
- CDS can confirm renal arteries



BLADDER AND FLUID

- Kidneys start producing urine around 9 weeks
- By 14-16 weeks, 2/3 of AFV from kidneys
- Bladder visible 98% by 12-13 weeks
- Bladder fills/empties around every 25 min



MEGACYSTIS FIRST TRIMESTER

- Sagittal bladder diameter >7 mm
- 7-15 mm
 - 90% resolve if no chromosomal abnormality
- >15 mm almost all have obstructive uropathy



APPROACH TO FETAL GU ASSESSMENT

THINGS TO CONSIDER

- Is the bladder present?
- Are kidneys present?
 - number, position, size, echogenicity, cysts
- Is urinary tract dilated?
 - level of obstruction
- Unilateral or bilateral?
- Oligohydramnios?
- Fetal gender?

GENITOURINARY ABNORMALITIES

Nephropathy

MCKD
Agenesis
PCKD

Obstructive Uropathy

UPJ
UVJ
PUV
Urethral atresia

Syndromes

Tri 13
Meckel Gruber
Beckwith Wiedemann
VHL

APPROACH

- Are kidneys present and do they look normal?
- Is bladder seen? Normal size?
- Is fluid (ie. lung maturation) compromised?
- Is problem nephropathy or uropathy? or both?
- Hereditary or non-hereditary?
- Antenatal follow up?
- Postnatal follow up?

KEY POINTS TO REMEMBER



- “B-F-F-F”
 - Bladder?
 - Fluid?
 - Familial?
 - Followup?

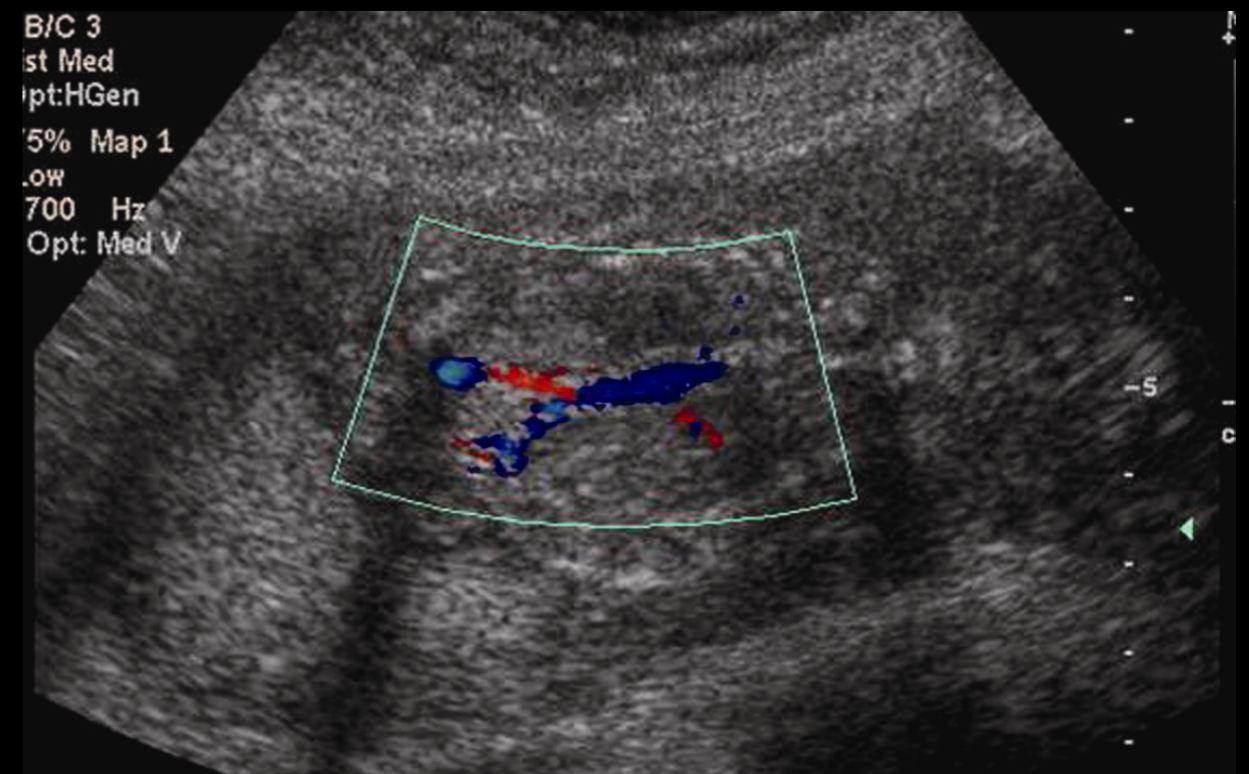
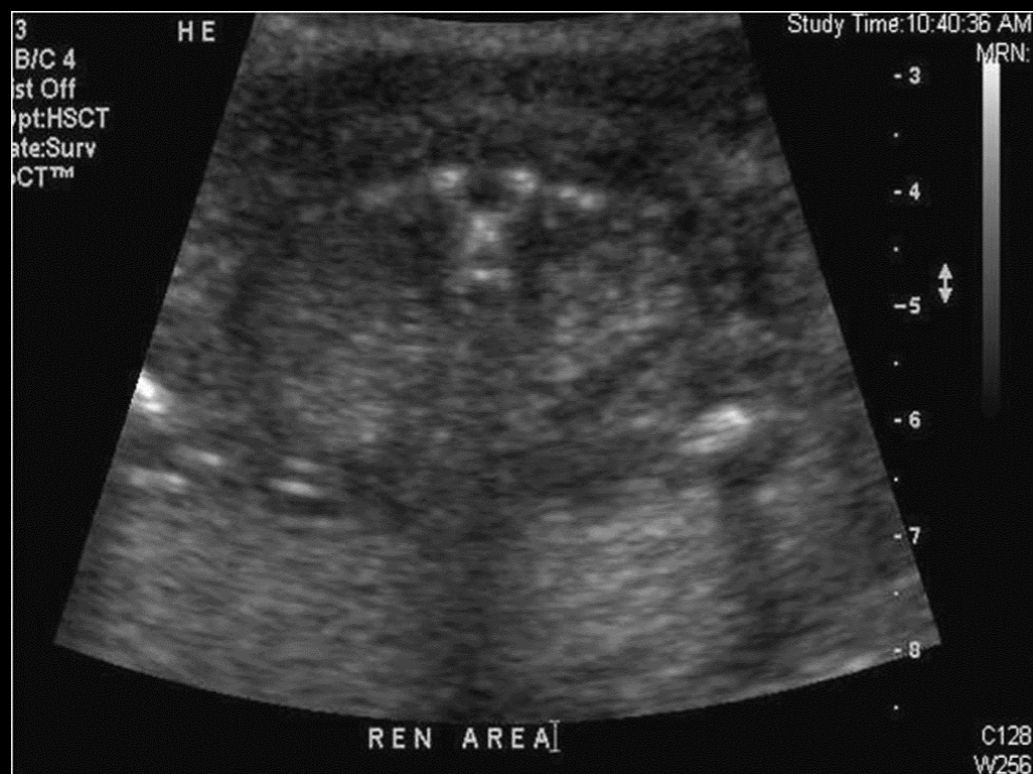
RENAL AGENESIS AND ECTOPIA

BILATERAL RENAL AGENESIS

- Lethal
- Ureteric bud fails to develop
- 1 in 4000 births
- Recurrent risk 4% for subsequent pregnancies
- Risk of silent renal GU anomalies in family members

BILATERAL RENAL AGENESIS

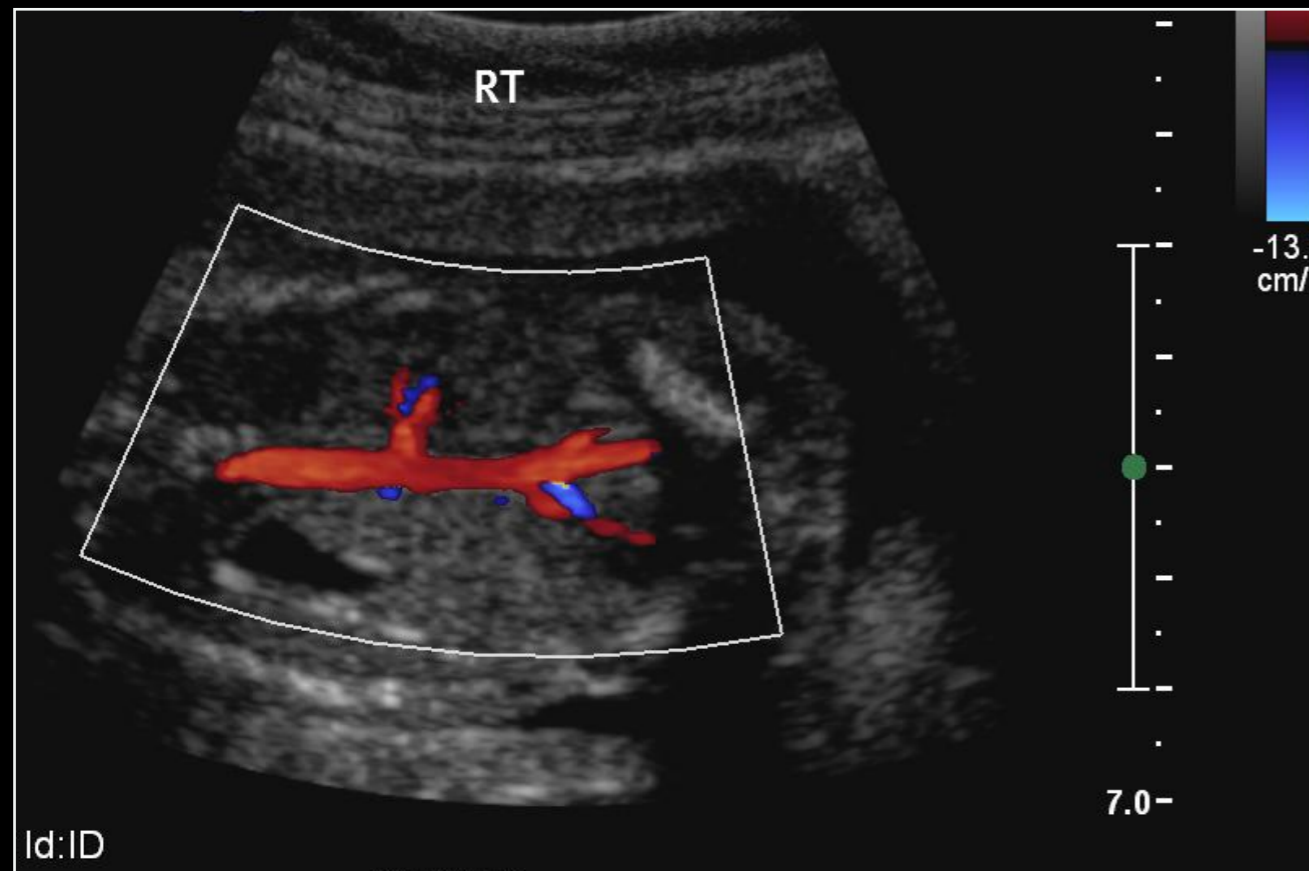
- Severe oligohydramnios/anhydramnios
- Non visualization of bladder for > 1 hour
 - Warning: Urachal diverticulum or retrograde filling
- Absent renal arteries



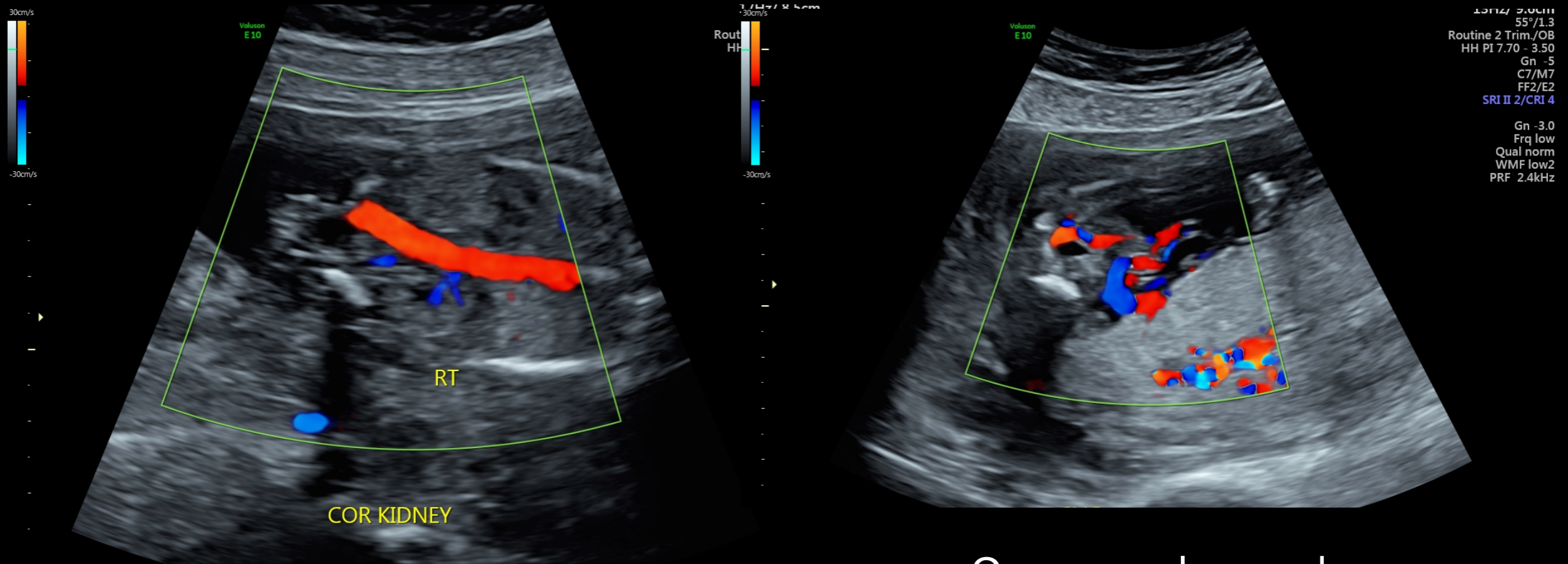
UNILATERAL RENAL AGENESIS

- 1 in 1000 births
- Contralateral kidney may be enlarged
- Contralateral renal anomalies:
 - VUR
 - Associations: Cardiac, skeletal, GI
- If isolated, good prognosis
- Recurrence 1% if parents normal, 7% if one parent has solitary kidney

UNILATERAL RENAL AGENESIS



UNILATERAL RENAL AGENESIS

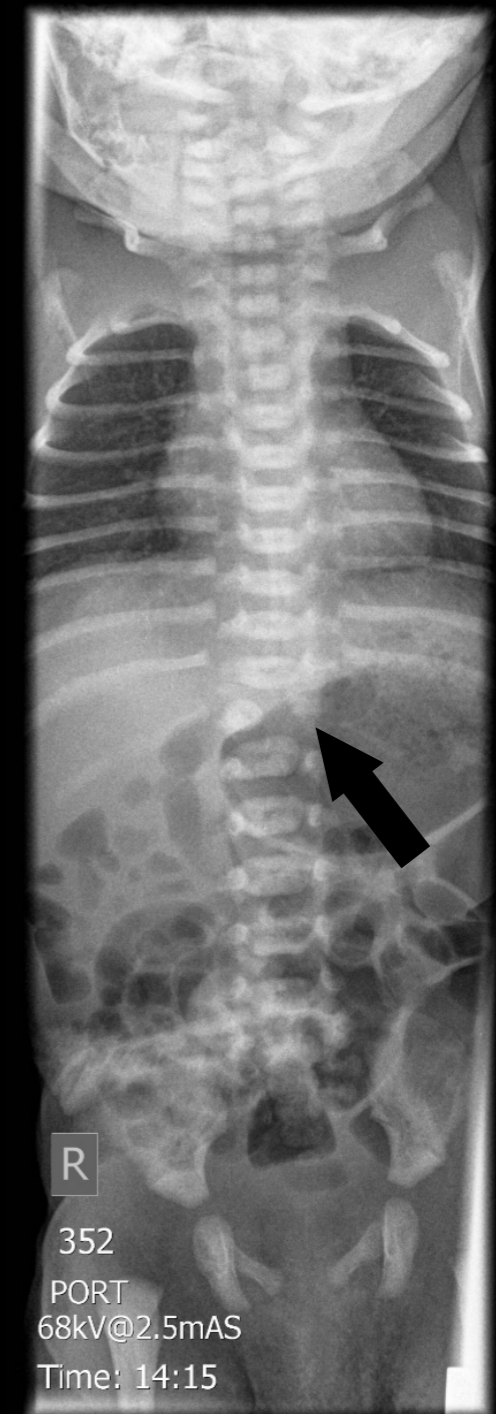


2 vessel cord

UNILATERAL RENAL AGENESIS

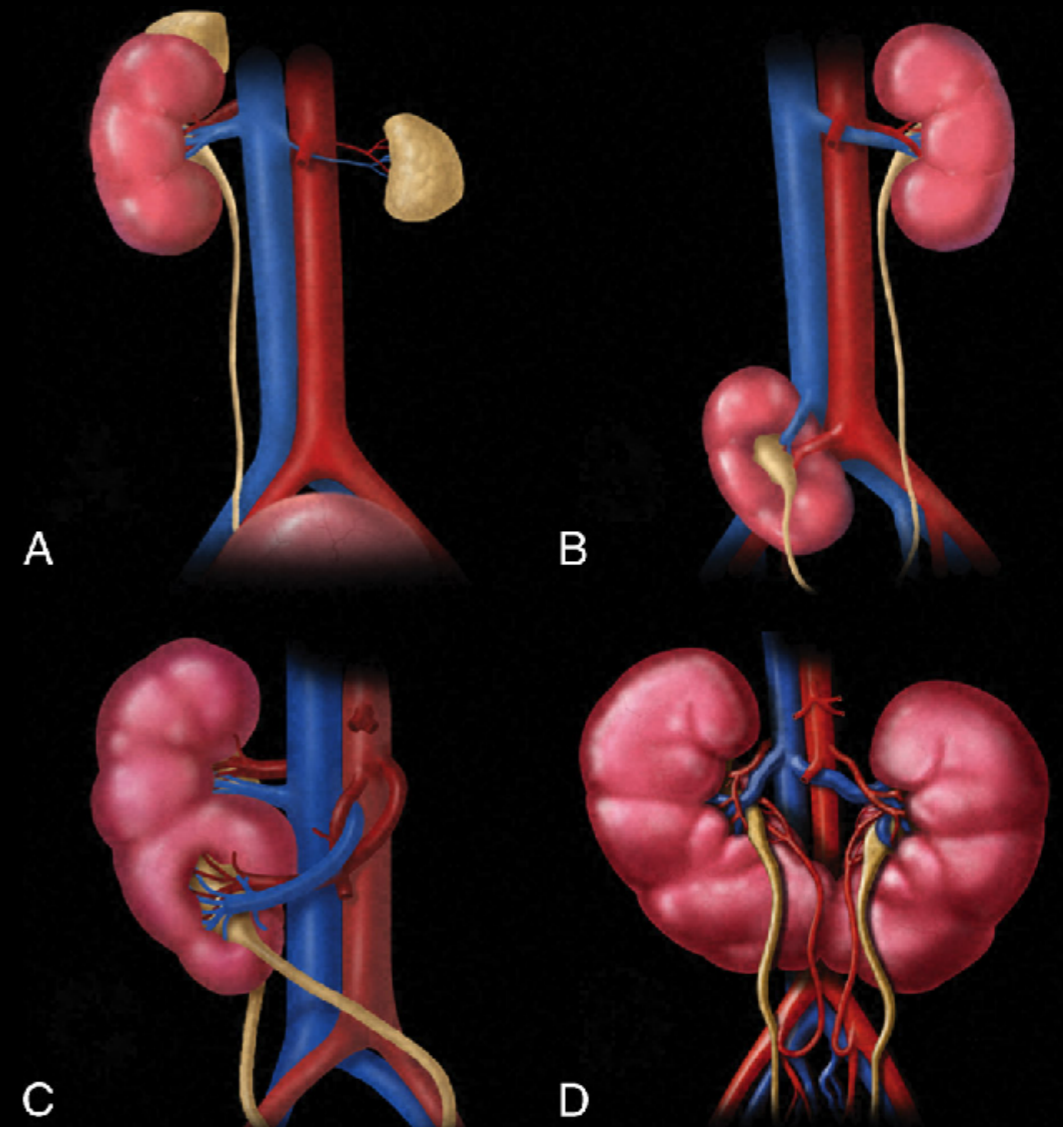
Hemivertebra

2D
41%
C 58
P Low
HGen

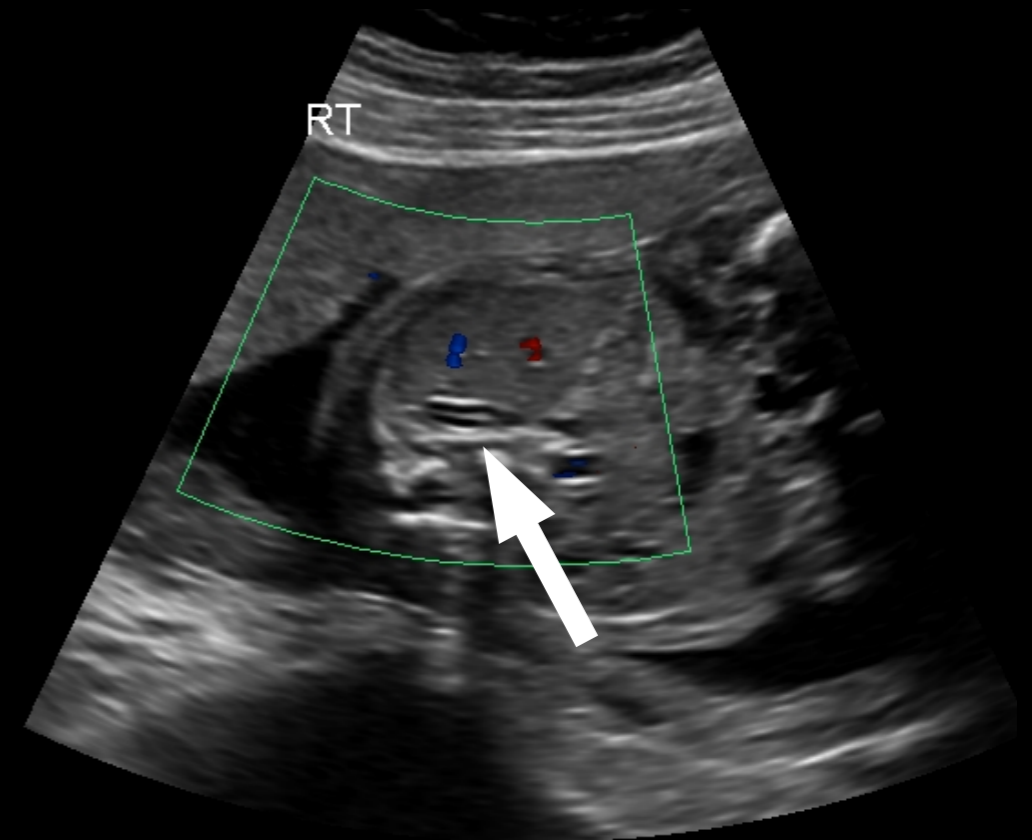


ECTOPIC KIDNEY

- Incidence of ectopic kidney 1 in 1200
- Pelvic most common
 - scan adjacent to bladder and iliacs
- Crossed renal ectopic:
 - with fusion
 - without fusion
 - *distinguished from duplex by angulation between two kidneys
- Associations: Genital, skeletal, GI, VUR



ECTOPIC KIDNEY





1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000



0.8
10C3
dMTA 0
31 fpa
G.73
DR.70
A.4
P.1

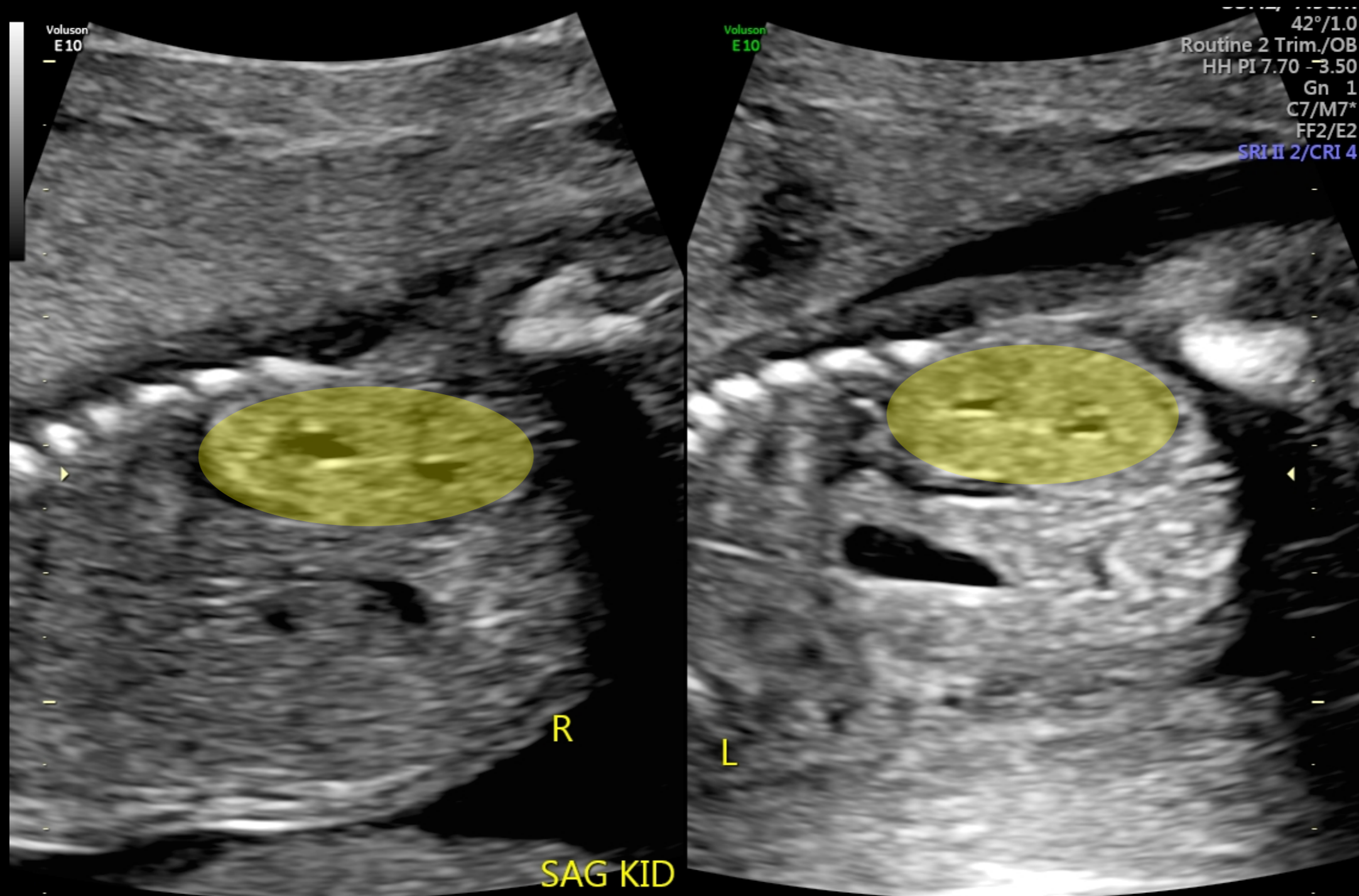
ECTOPIC KIDNEY FOLLOW UP



DUPLEX KIDNEY

- Two ureteral buds give rise to duplex kidney
- Two pelvicaliceal systems
- Partial or complete ureteral duplication
- Upper and lower pole moieties in same plane
- Obstruction upper pole moiety + ureterocele common
- Reflux common lower pole moiety

DUPLEX COLLECTING SYSTEM



DUPLEX COLLECTING SYSTEM



DUPLEX COLLECTING SYSTEM



CYSTIC RENAL DISEASES

CLASSIFICATION OF CYSTIC RENAL DISEASES

- Hereditary
 - ARPKD
 - ADPKD
 - Glomerulocystic disease
 - Medullary cystic dysplasia
- Non-Hereditary
 - MCDK
 - Obstructive dysplasia

ARPKD

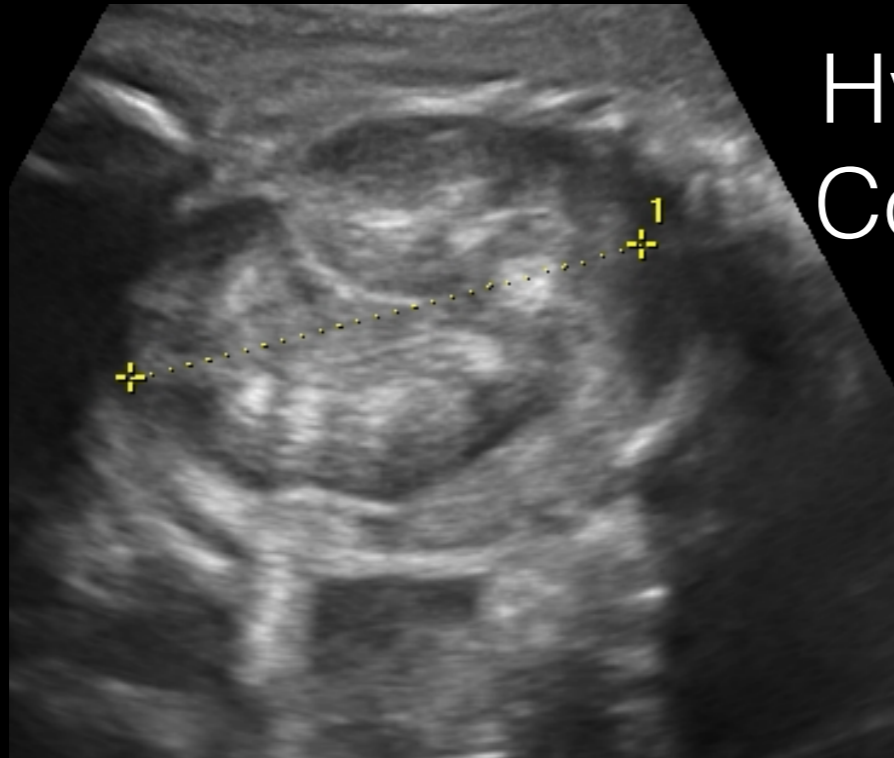
- 1 in 20,000 live births
- Enlarged hyperechoic smooth kidneys
- Evolution of cystic changes through third trimester
- Cortex is spared - hypoechoic rim sign
- Reversal of CMD can be seen
- Low fluid
- Recurrence risk: 25%

ARPKD

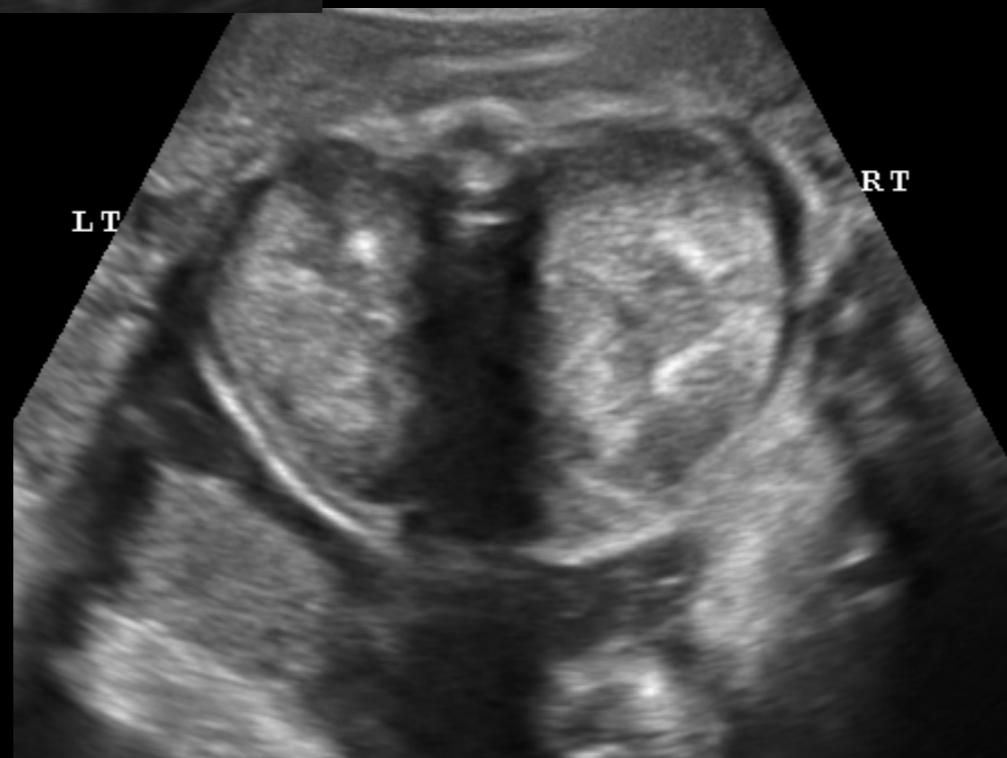
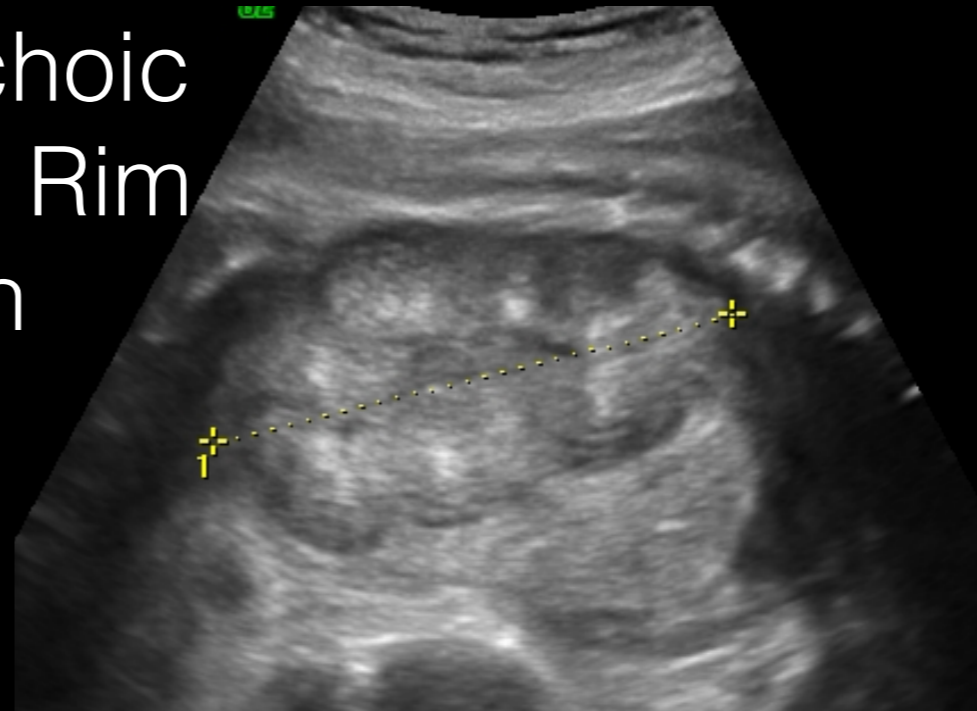


21 week anatomy scan
Enlarged kidneys: 26mm and 28 mm

ARPKD

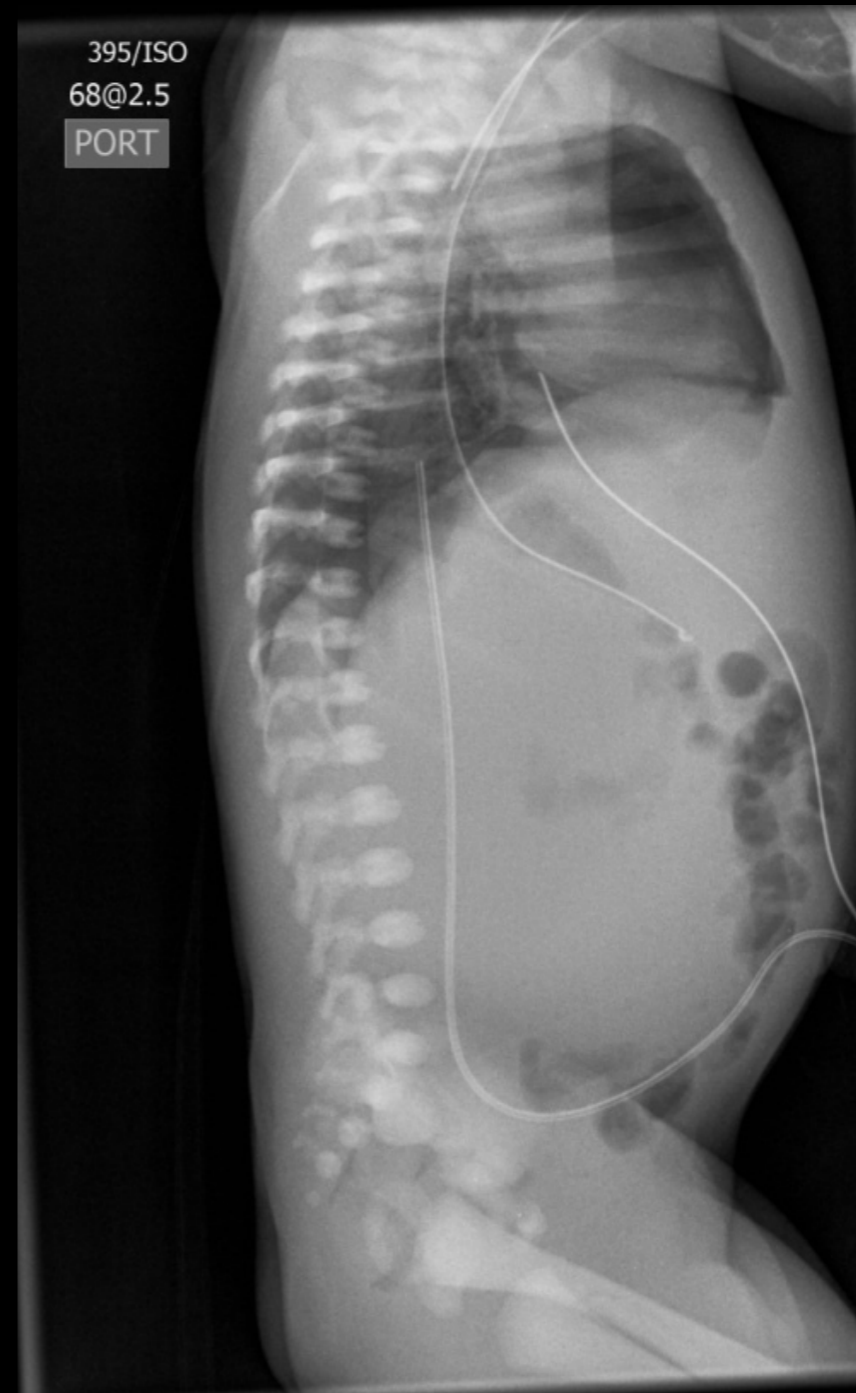
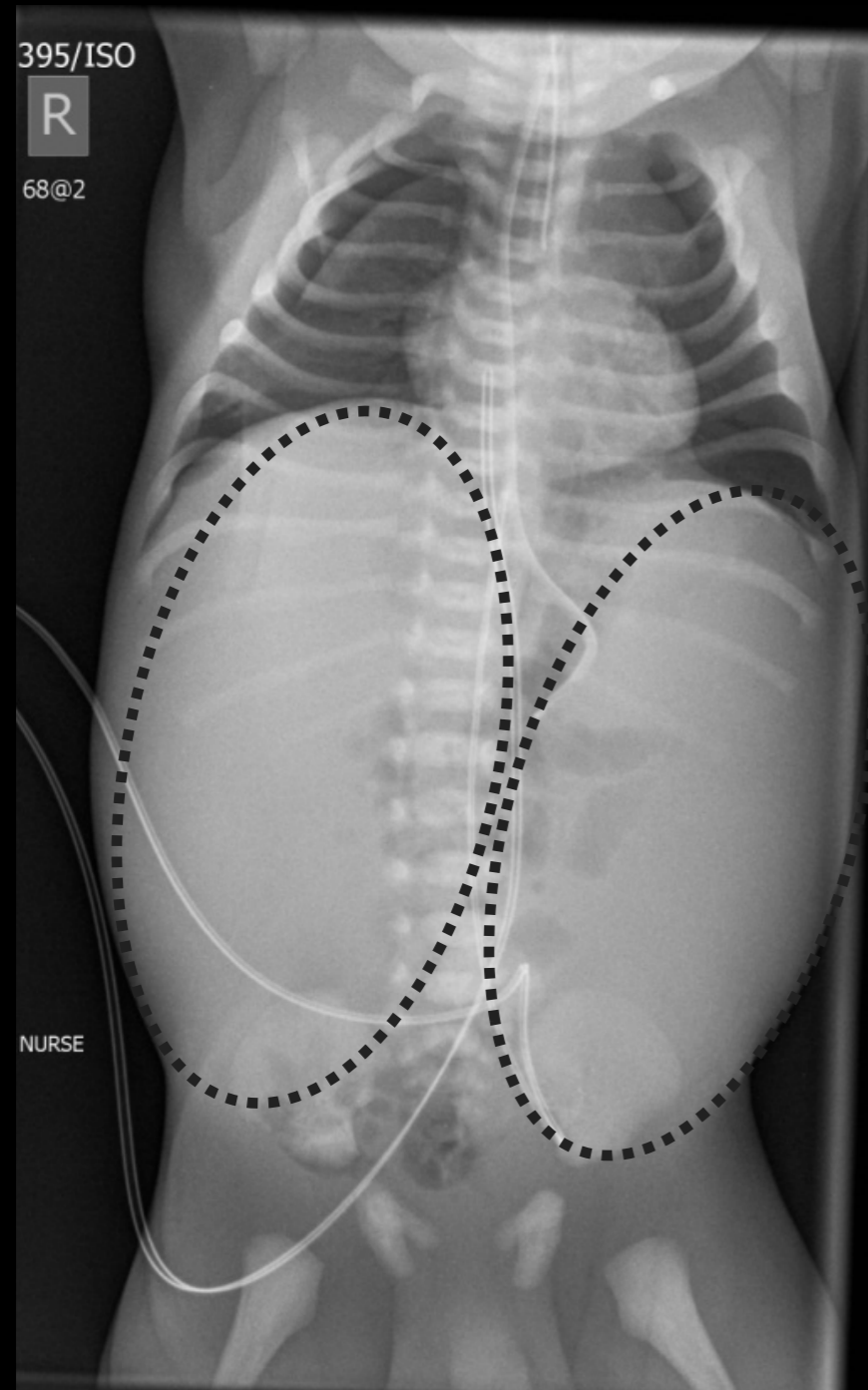


Hypoechoic
Cortical Rim
Sign



31 weeks:
Bilateral
enlarged
kidneys

ARPKD



ARPKD

Postnatal Images

FR 29Hz
S1

2D
70%
C 61
P Low
Gen



M3



RT KIDNEY TRV

JPEG

6.0

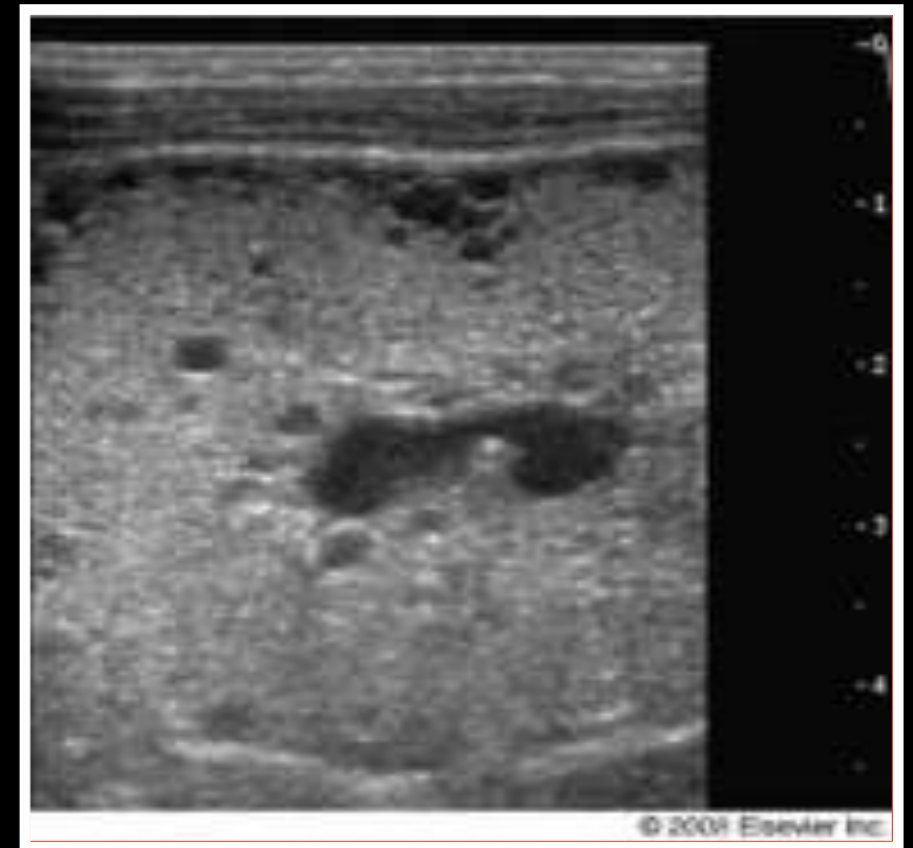
*** bpm

ADPKD

- 1 in 800 live births
- Moderately enlarged kidneys with hyperechoic cortices
- Usually normal AFV
- Cysts usually don't develop until adulthood
- Association: duplex, MCDK, UPJ obstruction
- Ask about family history, scan parents

GLOMERULOCYSTIC KIDNEYS

- Cysts corresponding to dilated Bowman spaces
- Nonspecific origin
 - Sporadic
 - Familial
 - Syndromes (TS, Tri 13, Zellwegger, Short rib polydactyl, Orofaciodigital syndrome type 1)
- Classic appearance is enlarged kidney with subcapsular cortical cysts



Callen 2013

MEDULLARY CYSTIC DYSPLASIA

- Cysts involve medullary tubules
- Associated with many syndromes including Meckel-Gruber
- Present early with enlarged kidney, pseudo CMD, prominent medulla

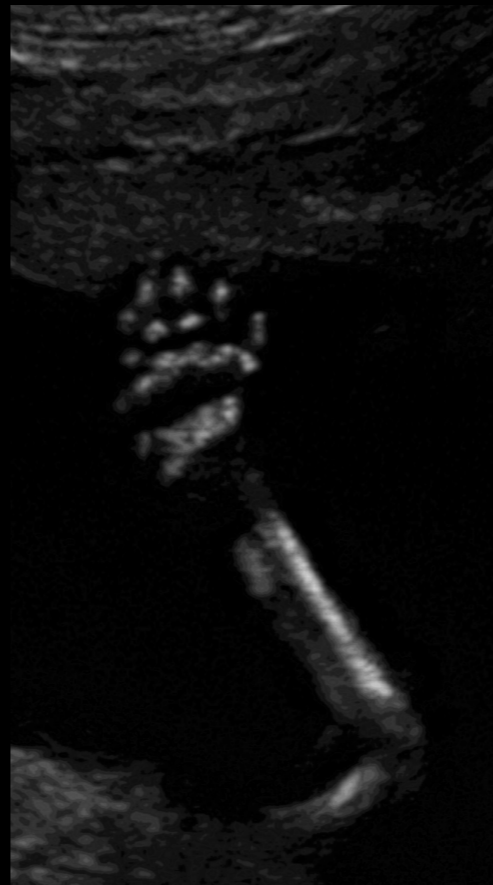


Callen 2013

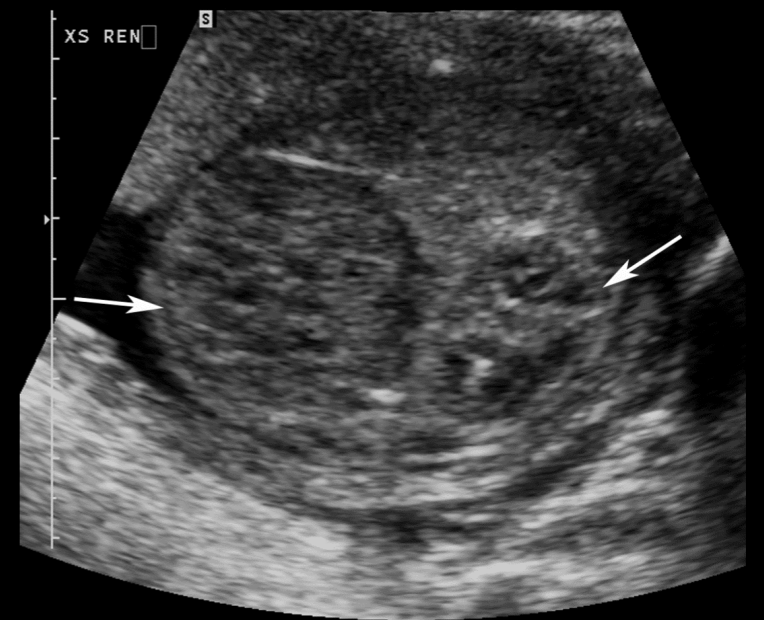
MECKEL GRUBER SYNDROME



Encephalocele



Polydactyly

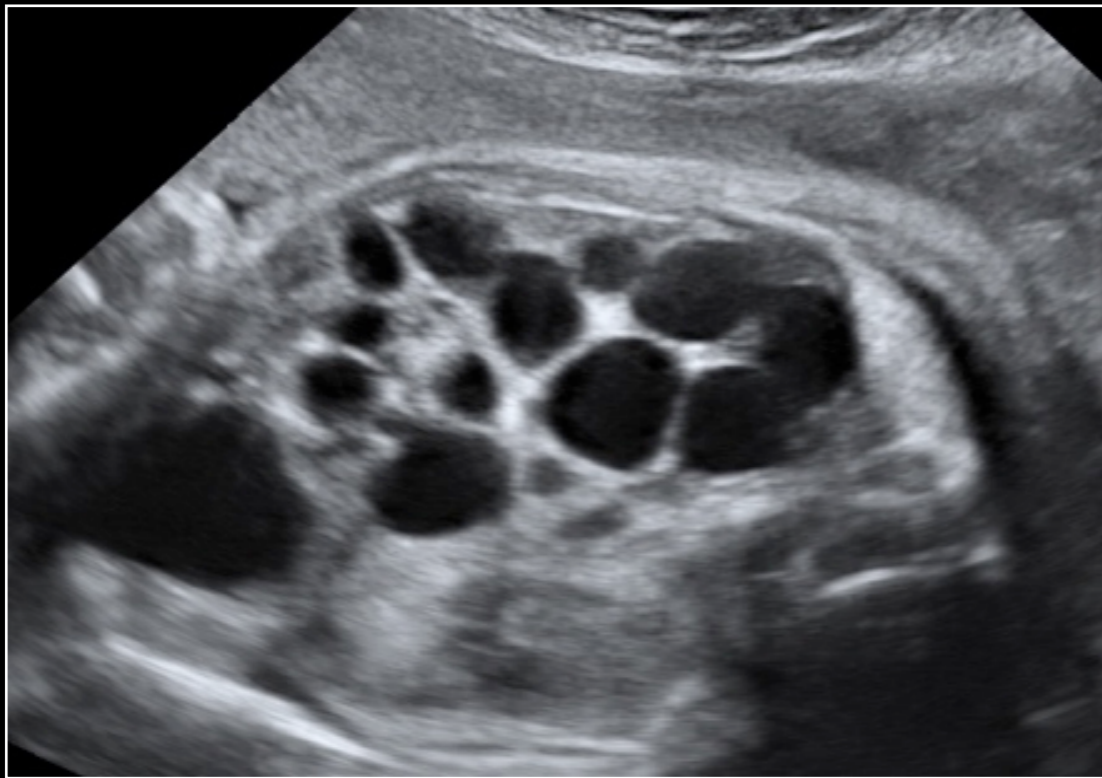


Kidney Cysts

MULTICYSTIC DYSPLASTIC KIDNEY

- Unilateral noncommunicating cyst of varying size/shape
- Irregular contours
- No normal tissue between cysts, no collecting system
- Can occur in upper moiety of duplex
- May involute during pregnancy or after birth
- Association: UPJ, VUR, agenesis
- Unilateral or bilateral (up to 25%)

MCDK VS HYDRONEPHROSIS



Irregular contour
Cysts vary in size/shape
Noncommunicating
Dysplastic echogenic tissue



Smooth contour
Communicating 'cysts'
Rim of renal tissue

QUERY EARLY MCDK



FOLLOW UP: UNILATERAL MCDK



OBSTRUCTIVE CYSTIC RENAL DYSPLASIA

- Unilateral (UPJ or UVJ)
- Bilateral (bladder outlet obstruction)
- Variable appearance
- Usually cysts are subcapsular

ECHOGENIC KIDNEYS

ECHOGENIC KIDNEYS

- Recall: Early in pregnancy normal kidney is echogenic
- Finding not a diagnosis
- Differential considerations:
 - PCKD (AR and AD)
 - Syndromes: Tri 13, Meckel Gruber, Beckwith Wiedemann, Perlman, Zellwegger, Bardet-Biedl
 - Renal vein thrombosis (risks: maternal diabetes, TTTS)
 - Infection: CMV
 - Congenital nephrotic syndrome (rare**) - assoc. thick placenta
 - May be normal

ECHOGENIC KIDNEYS

- COMMON:

- Physiologic variation
- Obstructive
- ARPKD or ADPKD



- UNCOMMON:

- Meckel-Gruber
- Bardet-Biedl
- Aneuploidy
- Infection
- RVT
- Congenital Nephrotic Syndrome
- Overgrowth Syndromes
 - Beckwith-Wiedeman
- Vater syndrome

ECHOGENIC KIDNEYS

- Prognosis defined by etiology
- Assess for:
 - Unilateral vs bilateral
 - Oligohydramnios
 - Obstruction
 - Parenchymal changes
 - CMD?
 - Cysts?

ECHOGENIC KIDNEYS

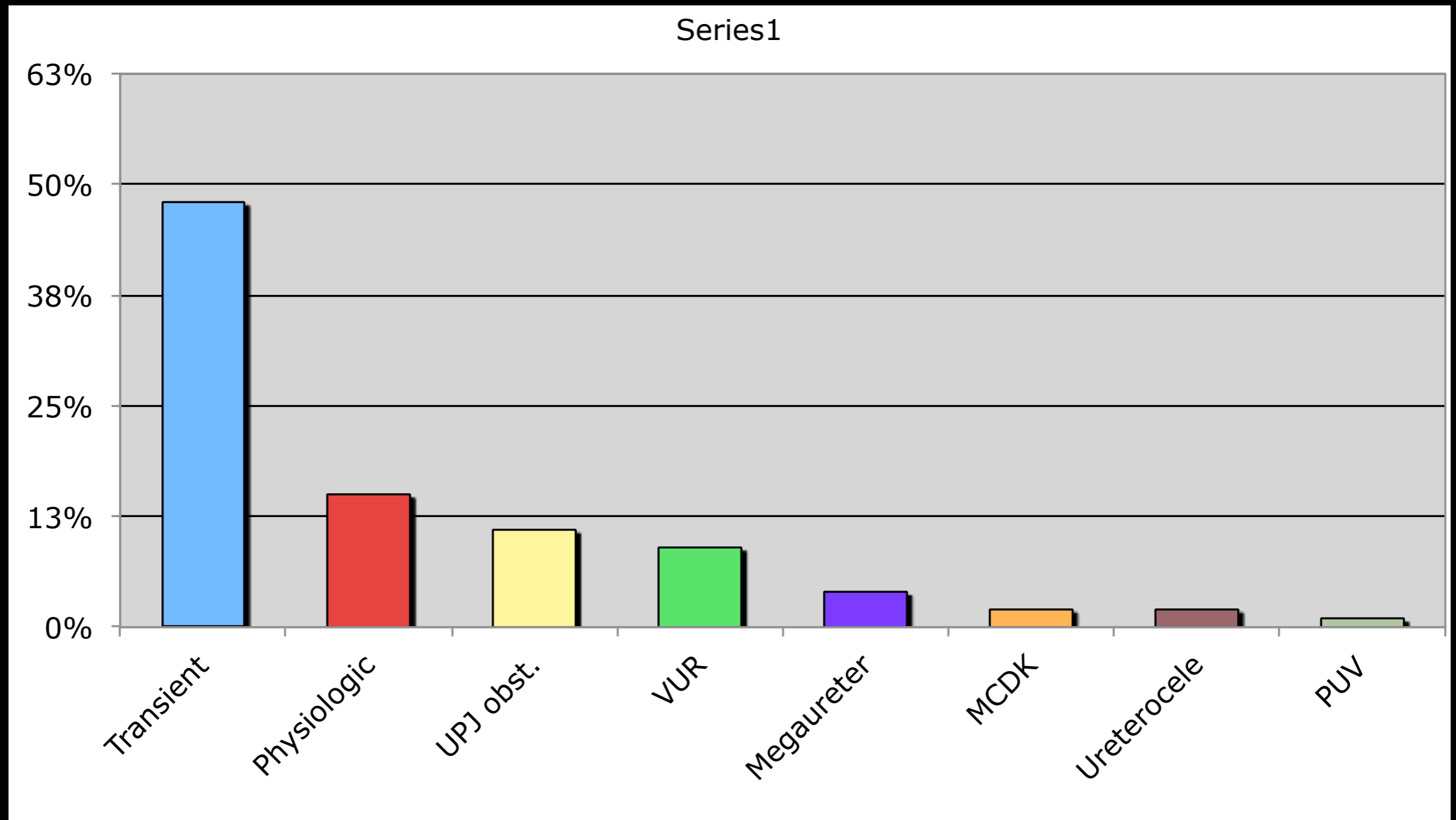
Hyperechoic Kidneys	Corticomedullary Differentiation
Beckwith Weideman, Perlman, Zellwegger, Infection, Intoxication, MCD, maternal, normal variant	Present
Obstructive dysplasia, ARPKD	Absent
ADPKD, Diabetes, Bardet Biedl, RVT, Meckel Gruber, Chromosomal, Nephrotic	Variable
Some ARPKD, metabolic	Reversed

URINARY TRACT DILATATION

UPPER URINARY TRACT DILATATION

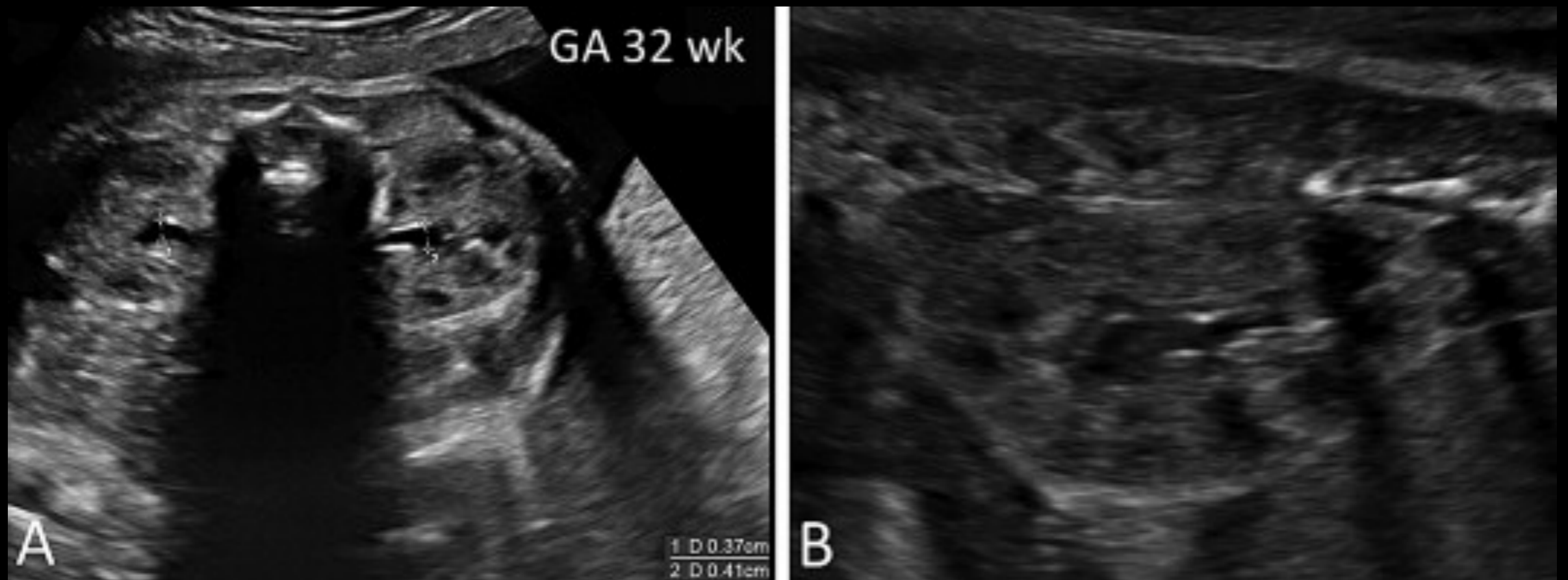
- Upper tract dilatation most common abnormality 1-5%
- Measure AP diameter renal pelvis (APD) in transverse plane
- Hydronephrosis: dilatation of pelvis and calyces
- Pyelectasis: dilatation of pelvis only
- Various etiologies:
 - Transient/physiologic
 - VUR
 - Obstructive

UPPER URINARY TRACT ETIOLOGY



HOW TO MEASURE

- Transverse plane measure AP diameter of renal pelvis:

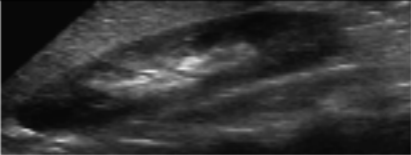
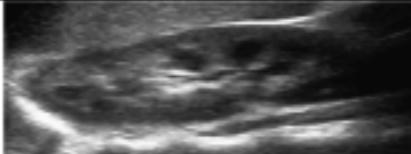
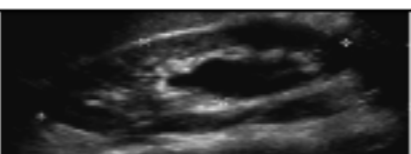
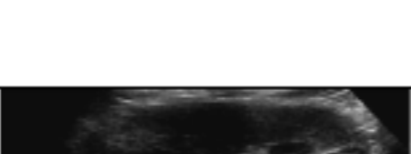



URINARY TRACT DILATATION THRESHOLD

- Langer et al 1996
 - 5 mm < 28 wks
 - 10 mm > 28 weeks
- Grignon et al 1986
 - Grade 1: APD 1 cm no caliectasis
 - Grade 2: APD 1-1.5 cm and no caliectasis
 - Grade 3: APD > 1.5 cm + slight caliectasis
 - Grade 4: APD > 1.5 cm + moderate caliectasis
 - Grade 5: APD > 1.5 cm + severe caliectasis + cortical atrophy

SFU GRADING

Table 1 Society of Fetal Urology grading system of congenital hydronephrosis

Grade	Central renal complex	Renal parenchymal thickness	Ultra sound scan
0	intact	Normal	
I	Slight splitting of pelvis	Normal	
II	Evident splitting of pelvis and calices	Normal	
III	Wide splitting of pelvis and calices	Normal	
IV	Further splitting of pelvis and calices	Reduced	

PYELECTASIS CUT-OFF VALUES

- SFU GRADING SECOND TRIMESTER:
 - Mild 4-7 mm
 - Moderate 7-10 mm
 - Severe > 10 mm
- SFU GRADING THIRD TRIMESTER:
 - Mild 7-9 mm
 - Moderate 9-15 mm
 - Severe > 15 mm
- Lee et al study
 - >15 mm 88% chance post natal pathology

SFU CONSENSUS STATEMENT

- AP diameter of the renal pelvis of > 4 mm in the 2nd trimester and > 7 mm in 3rd trimester warrants further follow up in prenatal period
- Follow up:
 - Repeat US in 3rd trimester
 - Ultrasound at birth and 1 month

PROGNOSTIC FACTORS

- 80% of mild (4-7 mm) spontaneously resolve
- Severity of dilatation correlated to higher risk of pathology EXCEPT for VUR
- Progression of dilatation through to third trimester worse prognosis
 - 12% with isolated 2nd trimester UT dilatation had postnatal pathology
 - 40% if observed in both 2nd and 3rd trimester
- Worrisome findings: oligohydramnios, abnormal cortex, early GA at diagnosis

PROGNOSIS AHN

- Lee et al, 2006
 - Meta-analysis
 - 36% have underlying uropathy
 - 12% mild < 9 mm T3
 - 45% moderate 9-15 mm T3
 - 88% > 15 mm T3

UTD CONSENSUS 2014

- Consensus Statement 2014
- ACR, AIUM, ASPN, SFU, SMFM, SPR, SRU
- Recommendations:
 - Use of term UT dilatation
 - Classify based on:
 - APD, Caliceal dilatation (major/minor), parenchymal thickness, parenchymal appearance, ureter, bladder
 - Cut offs:
 - 16-27 weeks < 4 mm
 - ≥ 28 weeks < 7 mm
 - Postnatal (> 48h) < 10 mm

POSTNATAL WORK UP

- Low Risk:
 - One additional ultrasound > 32 weeks
 - Post natal ultrasound at birth (>48 hr) and 1 month
 - Modify aneuploidy risk if needed
- High Risk:
 - Follow up ultrasound 4-6 weeks after presentation
 - Postnatal ultrasound at birth and 1 month
 - Specialist consultation

OUTCOME ISOLATED ANTENATAL HYDRO

- Sighu Pedatr Nephrol (2006)
 - HSC
 - 7 articles selected that used SFU grading system
 - SFU grade 1-2 (APD < 12 mm)
 - 98% resolve, stabilize or improve
 - Conclusion: minimal investigation require
 - SFU grade 3-4 (APD > 12 mm)
 - more variable outcome

APD AS PREDICTOR FOR POSTNATAL SX

- Zhang et al, Pediatric Urology 2018
 - Systematic review and meta-analysis
 - 5 studies with total 1159 patients
 - Using 15 mm as cut off for APD:
 - Sensitivity 0.81
 - Specificity 0.78
 - Conclusion: APD >15 mm moderate diagnostic value predicting postnatal surgery

OUR CURRENT PRACTICE

- Isolated Antenatal Hydronephrosis:
 - 18-22 week anatomy APD > 4 mm, repeat at 32 weeks
 - If APD < 10 mm, no postnatal investigation
 - For APD ≥ 10 mm:
 - refer to nephrology clinic for postnatal management
 - trimethoprim 2 mg/kg/day started at birth
 - postnatal ultrasound after 48h

ANTENATAL HYDRONEPHROSIS

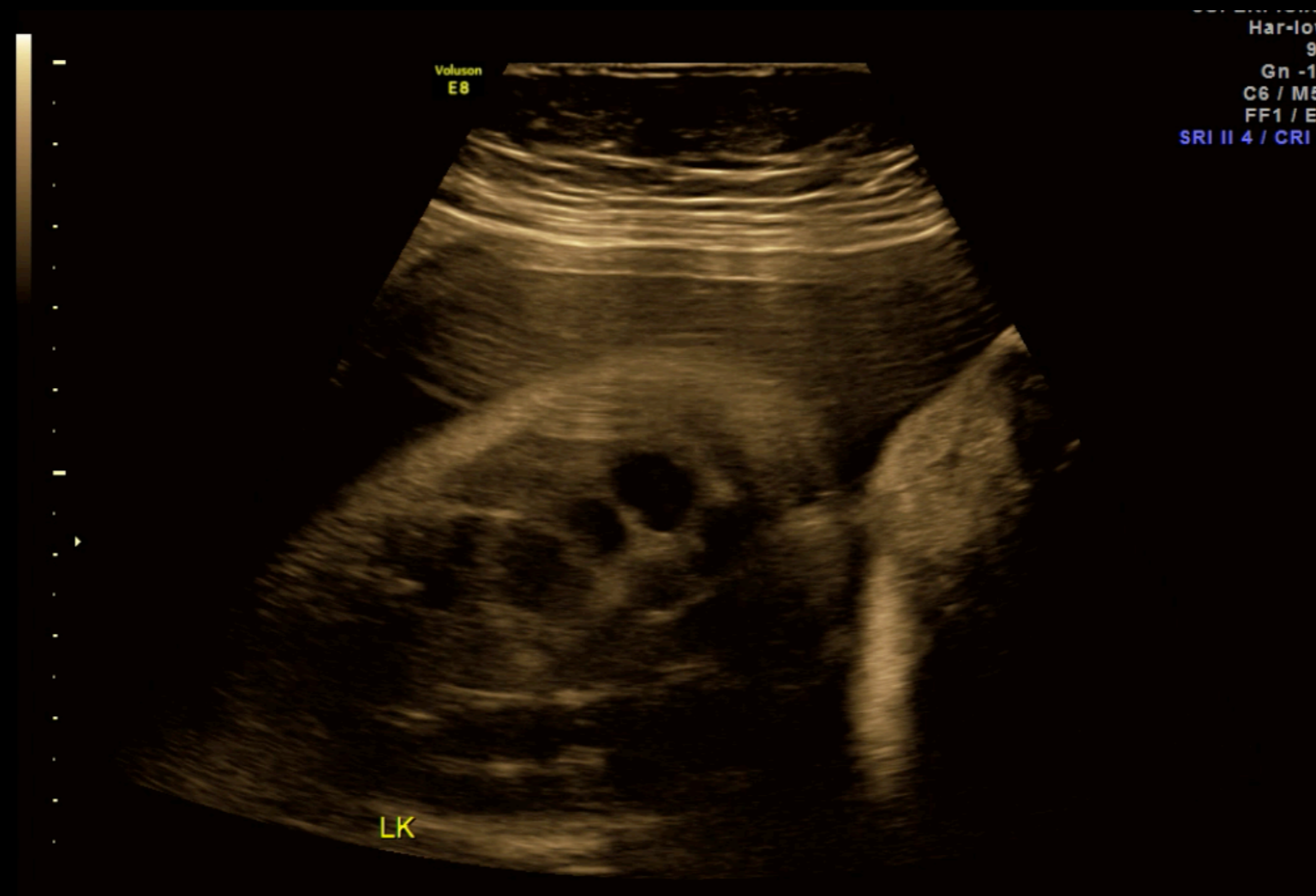
S
1.4
2
0%
58
Low
Pen



JPEG

*** b

ANTENATAL HYDRONEPHROSIS

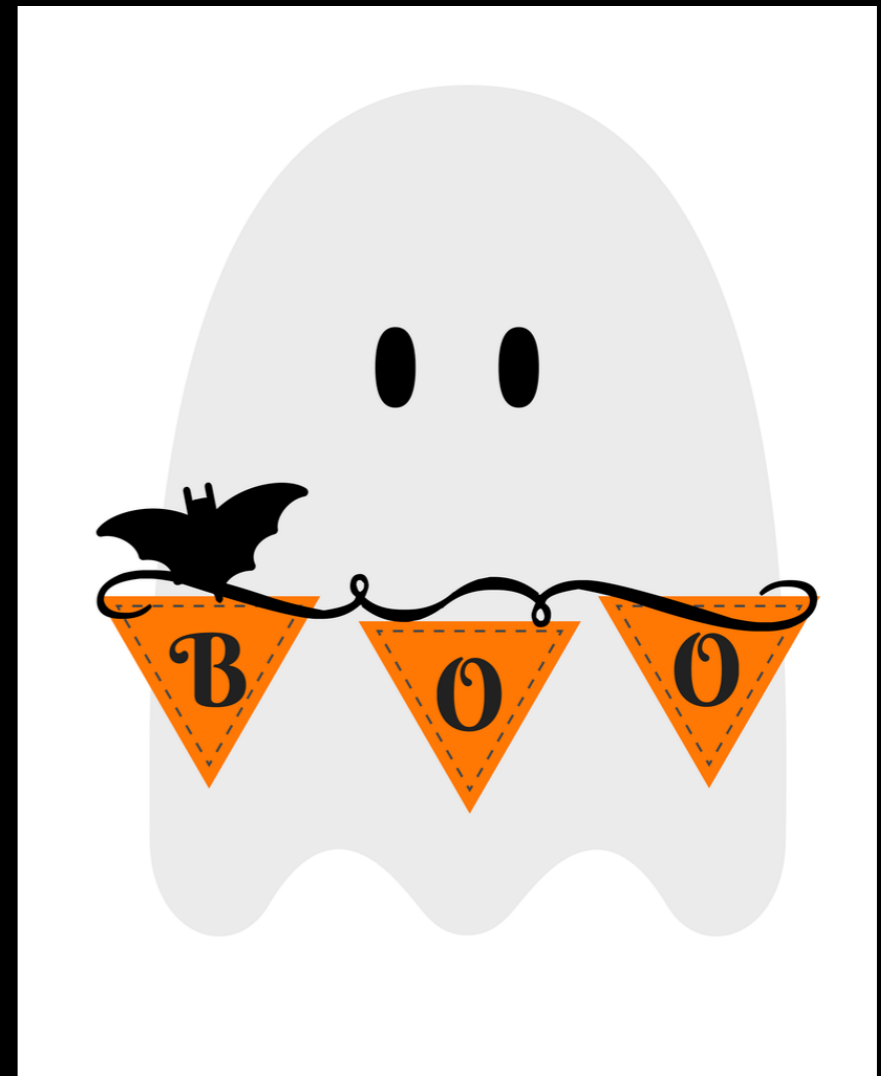


MEGAURETER

- Dilated ureter without bladder dilatation
- Usually result of UVJ obstruction
- May be associated with duplication of collecting system with ectopic ureterocele
- Increased risk of:
 - Unilateral agenesis
 - MCDK
 - Hirschsprung disease

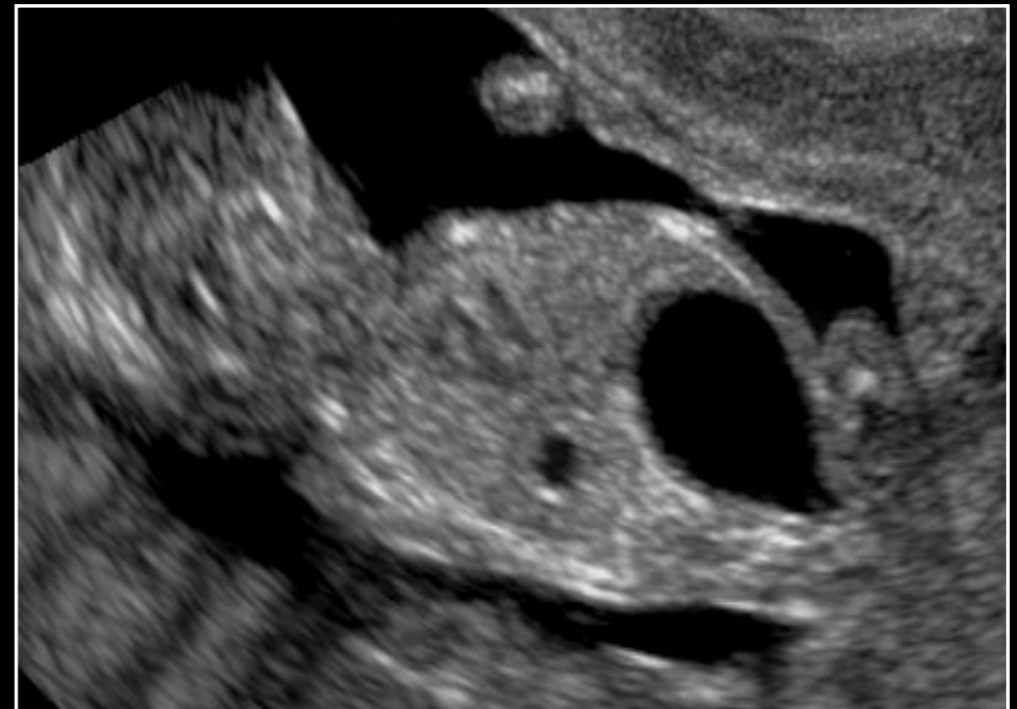
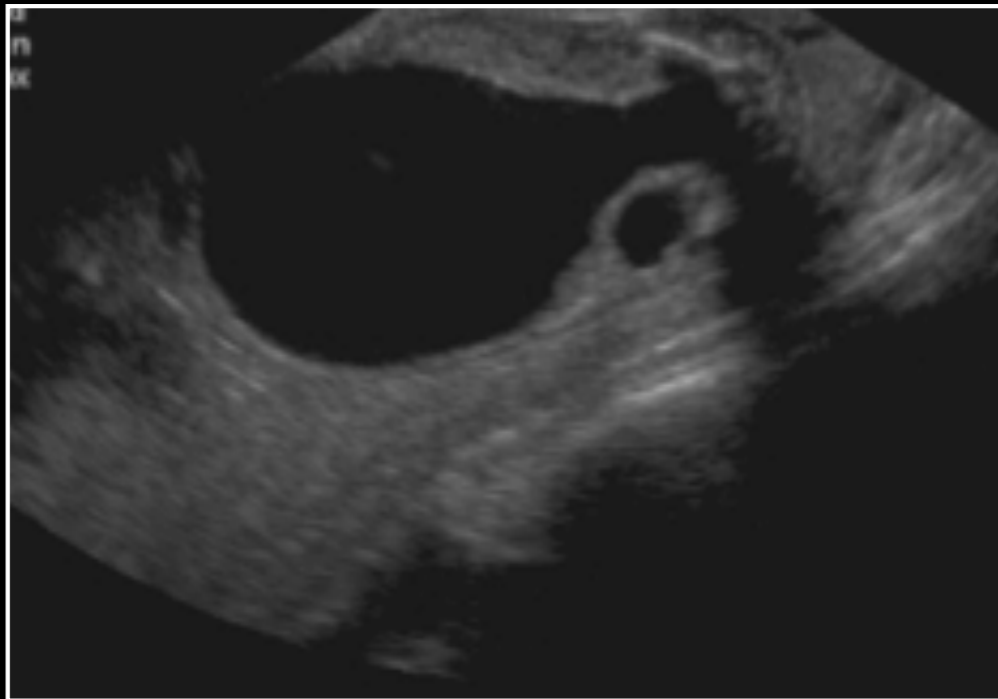
BLADDER OUTLET OBSTRUCTION (BOO)

- 1 in 3000 at 11-15 weeks
- Causes:
 - PUV
 - Urethral atresia/stricture
 - Prolapsed ureterocele
 - Prune Belly Syndrome
 - Megalourethra
 - Megacystic-Microcolon-intestinal hypoperistalsis syndrome (MMIHS)



POSTERIOR URETHRAL VALVES

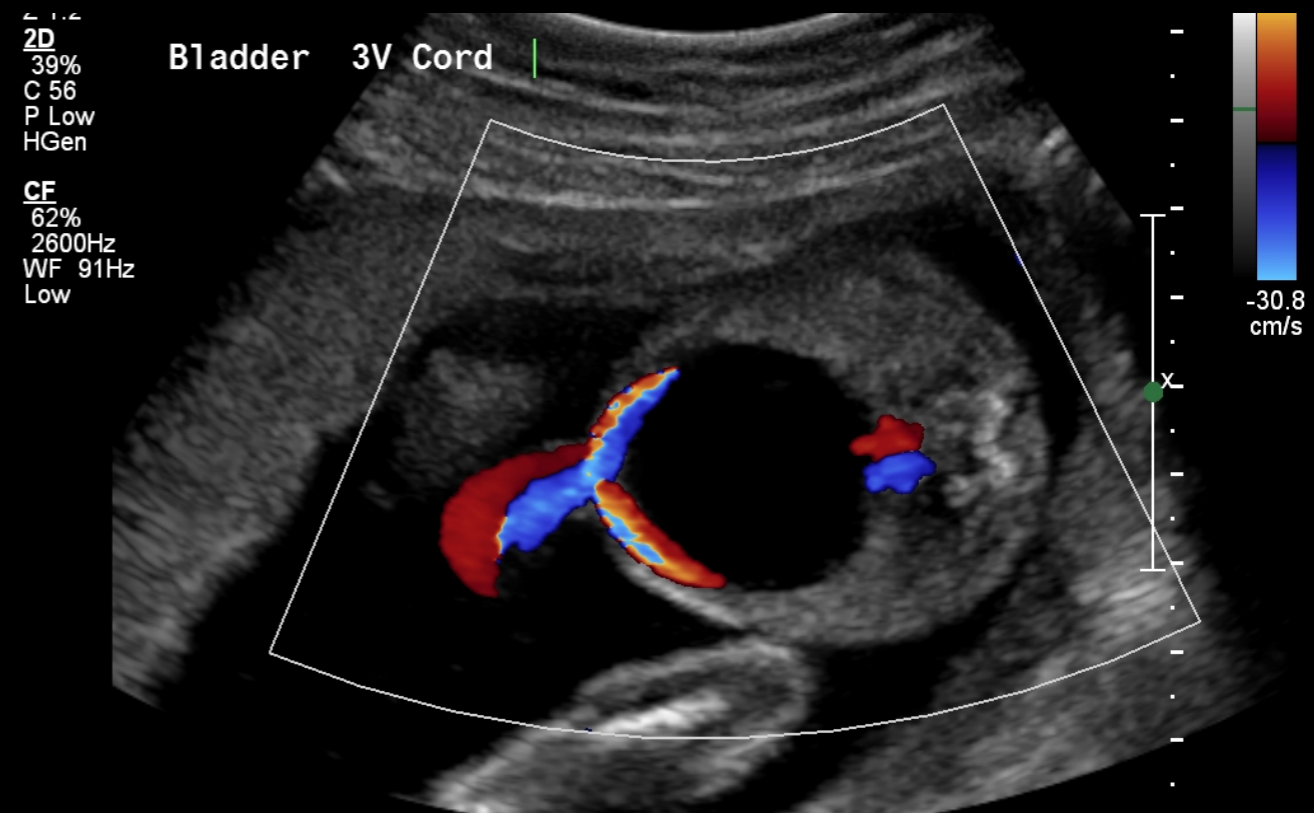
- Membranous folds in posterior urethra
- Most common of bladder outlet obstruction
- Predominantly male



Keyhole Sign

MMIHS

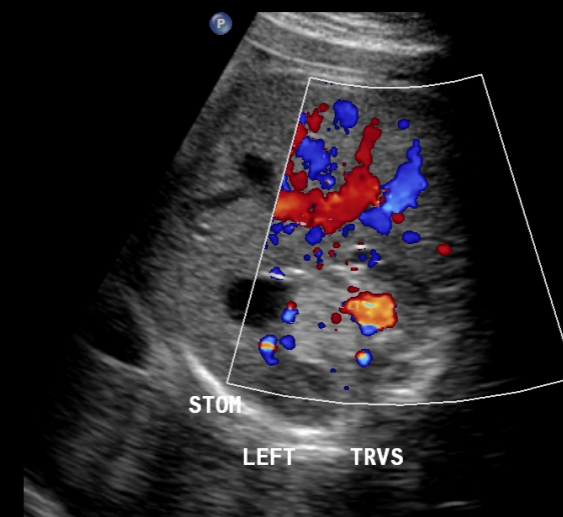
- All female
- Thin walled bladder
- Dilated ureters
- Hydronephrosis
- Normal parenchyma
- Normal AFV clue to diagnosis



RENAL TUMORS

RENAL TUMORS

- Congenital mesoblastic nephroma most common renal neoplasm in fetus and newborn
- Benign hamartoma made up of spindle cells
- Wilms tumor (malignant epithelial lesion) rare
- Features:
 - Echogenic solid mass replacing kidney
 - Assoc. with polydramnios
- Adrenal mass?
 - Neuroblastoma most common



Thank you

Kalesha Hack
kalesha.hack@sunnybrook.ca