

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Kaneko K, Tanaka S, Hasui M, et al. A family with X-linked benign familial hematuria. <i>Pediatr Nephrol.</i> 2010; 25(3):545-548.	Review/Other-Dx	1 family	Case report on a family with X-linked benign familial hematuria.	Result suggests that COL4A5 should be added to the list of causative genes for benign familial hematuria, although the mechanism(s) by which the same mutation leads to the distinct phenotypes, i.e. X-linked Alport syndrome or benign familial hematuria, remains unknown.	4
2. Kashtan CE. Familial hematuria. <i>Pediatr Nephrol.</i> 2009; 24(10):1951-1958.	Review/Other-Dx	N/A	Teaching article providing an overview of causes, diagnosis, and management of the major forms of familial hematuria, Alport syndrome, and thin basement membrane nephropathy.	N/A	4
3. Feld LG, Waz WR, Perez LM, Joseph DB. Hematuria. An integrated medical and surgical approach. <i>Pediatr Clin North Am.</i> 1997; 44(5):1191-1210.	Review/Other-Dx	N/A	To review microscopic and gross hematuria and define an approach to evaluation of hematuria.	The initial evaluation of gross or macroscopic hematuria may require only a urine culture, urine calcium-to-creatinine ratio, and renal and bladder US or a very detailed evaluation for renal parenchymal disease, stones, tumors, or anatomic abnormalities. Consultation with a pediatric nephrologist, urologist, or both is necessary in these instances.	4
4. Gordon C, Stapleton FB. Hematuria in adolescents. <i>Adolesc Med Clin.</i> 2005; 16(1):229-239.	Review/Other-Dx	N/A	To review causes and methods of evaluating hematuria in adolescents.	Renal US has little risk and is helpful in diagnosing many of the conditions requiring intervention. Serum studies offer little useful information in the evaluation of microscopic hematuria.	4
5. Patel HP, Bissler JJ. Hematuria in children. <i>Pediatr Clin North Am.</i> 2001; 48(6):1519-1537.	Review/Other-Dx	N/A	To review causes and evaluation of pediatric hematuria.	Complete urinalysis with a microscopic examination is the only test uniformly required for children with various presentations of hematuria. The rest of the evaluation is tailored according to the pertinent history, physical examination, and other abnormalities on the urinalysis.	4

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6. Crop MJ, de Rijke YB, Verhagen PC, Cransberg K, Zietse R. Diagnostic value of urinary dysmorphic erythrocytes in clinical practice. <i>Nephron Clin Pract.</i> 2010; 115(3):c203-212.	Observational-Dx	134 patients	To determine the diagnostic value of dRBC.	The cause of hematuria was proven in 68 patients (35% glomerular; 65% nonglomerular). Patients with glomerular disease had significantly more albuminuria and dRBC than patients with nonglomerular disease, but the %dRBC ranged from 1 to 50% and no optimal cutoff could be identified. Logistic regression analysis showed that %dRBC had a predicted probability to diagnose glomerular disease of 77.9% (area under the curve, AUC, 0.85). When %dRBC was combined with other risk factors such as serum creatinine, sex, age, dipstick erythrocyte or proteinuria score and number of casts, the predictive probability increased to 90.6% (AUC 0.97). Follow-up of the included patients showed no benefit of dRBC to identify patients at risk for glomerular disease. The diagnostic value of routinely collected urinary dRBC to diagnose glomerular disease in patients presenting with hematuria is modest. However, including dRBC with other variables, such as age and erythrocyte score on dipstick testing may increase the sensitivity, but needs to be confirmed in another, preferably larger, population.	3
7. Benbassat J, Gergawi M, Offringa M, Drukker A. Symptomless microhaematuria in schoolchildren: causes for variable management strategies. <i>Qjm.</i> 1996; 89(11):845-854.	Review/Other-Dx	N/A	Review published data on frequency of underlying disorder in school children with microscopic or gross isolated hematuria (IH).	Authors found 5 reports of microscopic IH in screened asymptomatic schoolchildren, 3 reports of microscopic IH detected by case-finding and 5 surveys of kidney biopsies in referred children with microscopic and gross IH. The combined prevalence of 5 disorders was 0%-7.2% in children with microscopic IH detected by screening, and 3.3%-13.6% in those with microscopic IH detected by case-finding.	4

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8. Cileto BG, Jr., Stock JA, Kaplan GW. Hematuria in children. A practical approach. <i>Urol Clin North Am.</i> 1995; 22(1):43-55.	Review/Other-Dx	N/A	To review causes of hematuria in childhood and present a diagnostic strategy.	Microscopic examination of the urinary sediment is important in evaluating hematuria. Genitourinary (GU) imaging should be tailored to each clinical situation.	4
9. Fitzwater DS, Wyatt RJ. Hematuria. <i>Pediatr Rev.</i> 1994; 15(3):102-108; quiz 109.	Review/Other-Dx	N/A	To outline a plan for the evaluation of pediatric patient with hematuria.	The most important differentiating feature in differential diagnosis for hematuria is the presence or absence of proteinuria. Those with significant proteinuria deserve a rapid evaluation and early referral to a nephrologist while those with no proteinuria should be followed and a step-wise evaluation performed.	4
10. Hisano S, Kwano M, Hatae K, et al. Asymptomatic isolated microhaematuria: natural history of 136 children. <i>Pediatr Nephrol.</i> 1991; 5(5):578-581.	Review/Other-Dx	136	To evaluate the natural history of asymptomatic isolated microhematuria (ASH) detected by mass screening.	Study suggests prognosis of ASH is good. Renal biopsy is not indicated for children with ASH.	4
11. Lieu TA, Grasmeyer HM, 3rd, Kaplan BS. An approach to the evaluation and treatment of microscopic hematuria. <i>Pediatr Clin North Am.</i> 1991; 38(3):579-592.	Review/Other-Dx	N/A	To review an approach to the evaluation and treatment of microscopic or symptomatic hematuria in children.	Initial evaluation of microscopic hematuria in a healthy child involves looking for signs of life-threatening causes of hematuria. If signs are absent, a stepwise evaluation (includes microscopic examination of the urine for red blood cell casts, a test for proteinuria, serum creatinine, and serial follow-up) is recommended. Although renal biopsy may establish a diagnosis it seldom changes the treatment in a child with ASH.	4
12. Osegbe DN. Haematuria and sickle cell disease. A report of 12 cases and review of the literature. <i>Trop Geogr Med.</i> 1990; 42(1):22-27.	Review/Other-Dx	12	To review the pathophysiology of sickle cell-induced haematuria, its incidence rate, its diagnostic criteria and available modalities of treatment.	Study suggests that diagnosis of sickle cell induced haematuria should be based on identifiable features and not merely by exclusion of other lesions.	4
13. Tarry WF, Duckett JW, Jr., Snyder HM, 3rd. Urological complications of sickle cell disease in a pediatric population. <i>J Urol.</i> 1987; 138(3):592-594.	Review/Other-Dx	321 patients surveyed	Survey patients and review literature to define urologic complications of sickle cell disease in a pediatric population.	Urological problems realized are hematuria, urinary tract infection and priapism. Study found that priapism responds most often to nonsurgical therapy and rarely results in impotence in young sickle cell patients.	4

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14. Meyers KE. Evaluation of hematuria in children. Urol Clin North Am. 2004;31(3):559-573.	Review/Other-Dx	N/A	To review diagnosis and management of macrohematuria and microhematuria in children.	For macrohematuria, US is needed to exclude malignancy or cystic renal disease. For microhematuria, US yield remains unproven but the value of a normal renal US examination in terms of reassurance may justify its cost and time.	4
15. Park YH, Choi JY, Chung HS, et al. Hematuria and proteinuria in a mass school urine screening test. Pediatr Nephrol. 2005; 20(8):1126-1130.	Observational-Dx	1,044 children	To evaluate the significance of mass screening test in children with hematuria and proteinuria. Patient's history, physical examination, laboratory tests, kidney US and Doppler US were used.	Mass screening can detect chronic renal disease in its early stage.	3
16. Diven SC, Travis LB. A practical primary care approach to hematuria in children. Pediatr Nephrol. 2000;14(1):65-72.	Review/Other-Dx	N/A	To address the the current approach to evaluation of hematuria in children, a classification of children with hematuria into four distinct and easily identified clinical categories, and the development of an algorithm for application in the primary care setting	No results listed in abstract.	4
17. Blumenthal SS, Fritsche C, Lemann J, Jr. Establishing the diagnosis of benign familial hematuria. The importance of examining the urine sediment of family members. JAMA. 1988; 259(15):2263-2266.	Review/Other-Dx	300 patients	To describe patients with normal renal function for evaluation of hematuria, usually microscopic, in whom prior urologic and radiological studies had failed to determine the cause of bleeding.	Urinary sediment from the patients and first-degree relatives revealed hemoglobin and red blood cell casts; the inheritance pattern was consistent with autosomal dominant transmission. During follow-up for up to 18 years, renal function remained normal, thus confirming the diagnosis of benign familial hematuria. Immunoglobulin A nephropathy and Alport's syndrome were less common than benign familial hematuria and could be differentiated from it by history, physical examination, and routine laboratory testing. Since benign familial hematuria is a common disorder in adults with hematuria and normal renal function, urinary sediment from patients and family members should be examined before extensive urologic and radiological procedures are performed.	4

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18. Savige J, Rana K, Tonna S, Buzza M, Dagher H, Wang YY. Thin basement membrane nephropathy. <i>Kidney Int.</i> 2003; 64(4):1169-1178.	Review/Other-Dx	N/A	To provide a summary on thin basement membrane nephropathy (TBMN).	TBMN is one of the most common conditions affecting the kidney, and the knowledge of its prevalence and understanding its genetic basis is still ongoing.	4
19. Bergstein J, Leiser J, Andreoli S. The clinical significance of asymptomatic gross and microscopic hematuria in children. <i>Arch Pediatr Adolesc Med.</i> 2005; 159(4):353-355.	Review/Other-Dx	570 children	To evaluate the clinical importance of hematuria in children and the necessity for such an evaluation using a defined diagnostic protocol	Of 342 children with microscopic hematuria, no cause was uncovered in 274 patients. The most common cause discovered was hypercalciuria (16%), followed by post-streptococcal glomerulonephritis (1%). Of 228 children with gross hematuria, no cause was uncovered in 86 patients. The most common cause discovered was hypercalciuria (22%). Ten patients had clinically important structural abnormalities. Fifty-three patients qualified for renal biopsy; 36 had IgA nephropathy.	4
20. Stapleton FB. Hematuria associated with hypercalciuria and hyperuricosuria: a practical approach. <i>Pediatr Nephrol.</i> 1994; 8(6):756-761.	Review/Other-Dx	N/A	To review diagnostic criteria of excessive urinary excretion of calcium and uric acid. Emphasis is placed on differences in urinary calcium and uric acid excretion between infants and older children.	Few long-term consequences from hypercalciuria or hyperuricosuria have been identified, although some debate exists concerning the effect of chronic hypercalciuria upon bone mineralization.	4
21. Jequier S, Cramer B, Petitjeanroget T. Ultrasonographic screening of childhood hematuria. <i>Can Assoc Radiol J.</i> 1987; 38(3):170-176.	Observational-Dx	184 children	To define the value of US on pediatric patients with hematuria. Compared US and IVU results.	US and IVU were in agreement in 83% of patients. US gave additional information in 44 patients (40%) with 56 findings not detected using IVU. In six patients (5.5%), lesions were missed using US but detected using IVU. In the remaining 58 patients, IVU and US were equally informative. US is an excellent screening method for use in childhood hematuria and can replace IVU in patients with minor posttraumatic hematuria and in most with glomerular disease.	3

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<p>22. Zhai Y, Xu H, Shen Q, et al. Renal histological features of school-age children with asymptomatic haematuria and/or proteinuria: a multicenter study. <i>Nephrology</i> (Carlton). 2014;19(7):426-431.</p>	<p>Review/Other-Dx</p>	<p>112 patients</p>	<p>To investigate the renal histological features of school-age children with asymptomatic urine abnormalities.</p>	<p>A total of 112 asymptomatic children's renal biopsy data were studied. Most of the children (71%) received a renal biopsy because of isolated microscopic haematuria (IH), and these children were predominantly (60%) proven to have only mild lesions in the glomeruli. Approximately 30% of the children were biopsied because of asymptomatic proteinuria with or without microscopic haematuria (HP or isolated asymptomatic proteinuria (IP)), and these children were mostly (44-83%) indicated to have CPG, such as IgA nephropathy, focal segmental glomerulosclerosis, and Alport syndrome. The junior high school students had a greater percentage of HP than the primary school children. IgA nephropathy was the most common diagnosis in children who received renal biopsy because of HP.</p>	<p>4</p>

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23. Kasap B, Soylu A, Turkmen M, Kavukcu S. Relationship of increased renal cortical echogenicity with clinical and laboratory findings in pediatric renal disease. J Clin Ultrasound. 2006;34(7):339-342.	Review/Ot her-Dx	121 patients	To correlate the clinical and laboratory findings with increased renal cortical echogenicity in children with acute renal diseases.	There were 7 newborns and 114 children (67 male, 47 female) with increased renal cortical echogenicity with a mean (+/-SD) age of 7.0 (+/-4.4) years. The clinical diagnosis was anatomic abnormality (including vesicoureteral reflux, ureteropelvic junction obstruction, ureterovesical junction obstruction, double collecting system) in 9%, urinary tract infection in 21%, urolithiasis in 6%, nephrotic syndrome in 20%, glomerulonephritis in 32%, and other diseases in 12%. Hyperechogenicity was bilateral in 72%, right-sided in 19%, and left-sided in 9%. There were 81 patients in group 1 and 33 patients in group 2 (grade II, 29; grade III, 4). There was no statistically significant difference between the groups with regard to age, sex, and serum blood urea nitrogen level, serum creatinine level, uric acid level, urine pH, and specific gravity. Hematuria was more frequent in group 2, whereas proteinuria and pyuria incidences were similar in the 2 groups. In patients with hematuria, glomerulonephritis was the most common cause.	4

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24. Greenfield SP, Williot P, Kaplan D. Gross hematuria in children: a ten-year review. <i>Urology</i> . 2007; 69(1):166-169.	Review/Other-Dx	342 (272 boys (80%) and 70 girls (20%))	Review patients' charts to characterize the clinical presentation and diagnosis of gross hematuria.	Of the 272 boys, 52 (19%) had benign urethrorrhagia; 48 (14%) had trauma; and 48 (14%) had a urinary tract infection, and 10 of those also had urologic anomalies. Of the 342 patients, 45 (13%) had one or more congenital urologic anomalies. Of these, 45 patients, 20 boys and 2 girls had vesicoureteral reflux, 10 boys had posterior urethral valves, 7 boys and 1 girl had ureteropelvic junction obstruction, 7 boys had proximal hypospadias, 2 boys and 1 girl had ureterovesical junction obstruction, 2 boys and 1 girl had ureterocele, and 1 boy had caliceal diverticulum. Voiding cystourethrography is useful in those with suspicious US findings, urinary tract infection, or voiding symptoms. Cystoscopy should be reserved for the minority in whom hematuria persists or those with ambiguous imaging study findings.	4
25. Shin JI, Park JM, Lee JS, Kim MJ. Effect of renal Doppler ultrasound on the detection of nutcracker syndrome in children with hematuria. <i>Eur J Pediatr</i> . 2007; 166(5):399-404.	Observational-Dx	248 consecutive patients (216 with hematuria and 32 healthy)	To determine the accuracy of renal Doppler US in detecting nutcracker syndrome in children with hematuria.	The peak velocity (PV) at the aortomesenteric portion (P=0.003) and the PV ratios of the left renal vein (LRV) (P=0.003) were significantly higher in children with hematuria than in normal children, while the PV at the hilar portion was not different. Renal Doppler US has an effect on the detection of nutcracker syndrome.	3



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26. Youn T, Trachtman H, Gauthier B. Clinical spectrum of gross hematuria in pediatric patients. <i>Clin Pediatr (Phila)</i> . 2006;45(2):135-141.	Review/Other-Dx	100 patients	To examine the associated symptoms and causes of gross hematuria in children and adolescents who presented with this problem as their major clinical manifestation.	The remaining 82 patients (59 M: 23 F) had a mean age of 9.2 +/- 5.0 years. Glomerular gross hematuria was found in 24 patients. A cause was found in all of these patients, most commonly immunoglobulin A (IgA) nephropathy (n=13) and Alport syndrome (n=6). Nonglomerular gross hematuria was found in 56 patients, and the most common etiologies were hypercalciuria (n=9), urethrorrhagia (n=8), and hemorrhagic cystitis (n=7). No etiology was found in 26 patients with nonglomerular gross hematuria. No diagnosis was made in the case of 2 patients whose hematuria could not be defined as glomerular or nonglomerular. Telephone follow-up was performed in 18 of these children 4.0 +/- 3.2 years (range: 1-9 years) after the initial evaluation and showed that only 3 of these patients had had recurrences of gross hematuria. They and all of the other patients remained otherwise well.	4
27. Gleason PE, Kramer SA. Genitourinary polyps in children. <i>Urology</i> . 1994; 44(1):106-109.	Review/Other-Dx	18 patients	Retrospective review of presenting complaints, diagnostic evaluation, treatment, and natural history of children with GU polyps seen at a clinic.	GU polyps in children can be diagnosed with excretory urography, with voiding cystourethrography, or endoscopically. The biologic activity of these polyps is uniformly benign, and there have been no recurrences following complete excision.	4
28. Lee CC, Lin JT, Deng HH, Lin ST. Hematuria due to nutcracker phenomenon of left renal vein: report of a case. <i>J Formos Med Assoc</i> . 1993; 92(3):291-293.	Review/Other-Dx	1 patient	To report the diagnosis of LRV compression by a nutcracker phenomenon in an 11-year-old patient with 2-year history of recurrent painless hematuria.	Renal US study, selective left renal angiography and retrograde left renal venography showed evidence of compression of the LRV where it crossed between the aorta and the superior mesenteric artery (SMA). A needle biopsy of the right kidney revealed no abnormal histologic change.	4

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29. Takahashi Y, Akaishi K, Sano A, Kuroda Y. Intra-arterial digital subtraction angiography for children with idiopathic renal bleeding: a diagnosis of nutcracker phenomenon. Clin Nephrol. 1988; 30(3):134-140.	Review/Other-Dx	28 cases	To review the diagnosis of the nutcracker phenomenon in children with nonglomerular idiopathic renal bleeding.	In 22/28 cases, digital subtraction angiography (DSA) showed the entrapment of the LRV, or nutcracker phenomenon. Study suggests most nutcracker phenomenon should be diagnosed on US but notes that intra-arterial DSA is an important tool to establish the disease entity and ultrasonic criteria.	4
30. Lerena J, Krauel L, Garcia-Aparicio L, Vallasciani S, Sunol M, Rodo J. Transitional cell carcinoma of the bladder in children and adolescents: six-case series and review of the literature. J Pediatr Urol. 2010; 6(5):481-485.	Review/Other-Dx	6 cases	To review cases of transitional cell carcinoma of the bladder in children and adolescents.	Neither physical examination nor laboratory analysis revealed any significant abnormalities, but ultrasound showed exophytic intravesical lesions. Surgical resection was performed endoscopically. Histological studies showed grade I TCCB in all cases. The immediate postoperative period was uneventful and long-term follow up did not reveal recurrence. Despite its low incidence in children, TCCB must be suspected in the event of macroscopic haematuria. Ultrasound followed by cystoscopy are the ideal diagnostic tools for visualization of these tumours. Endoscopic resection proved effective in all the present cases. Follow up must be clinical with periodic ultrasound evaluation. Urine cytologic examination is ineffective. Periodic cystoscopy is indicated only in cases of clinical or ultrasonographic suspicion of recurrence.	4
31. Ander H, Donmez MI, Yitgin Y, et al. Urothelial carcinoma of the urinary bladder in pediatric patients: a long-term follow-up. Int Urol Nephrol. 2015;47(5):771-774.	Review/Other-Dx	8 patients	To report our experience and long-term follow-up data on pediatric patients with urothelial carcinoma (UC) of the urinary bladder.	Urothelial carcinoma of the urinary bladder was histologically verified in five male (66%) and three female (33%) patients. In one patient, papillary urothelial neoplasm of low malignant potential was detected. Median patient age at the time of diagnosis was 12 years (4-18 years). Mean tumor size was 2.2 cm (1.5-4 cm). After a median follow-up of 60 months (10-121 months), no recurrence was observed among our patients.	4

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32. Vianello FA, Mazzoni MB, Peeters GG, et al. Micro- and macroscopic hematuria caused by renal vein entrapment: systematic review of the literature. <i>Pediatr Nephrol.</i> 2016;31(2):175-184.	Review/Other-Dx	187 studies/736 patients	To conduct a systematic review of the literature for micro- and macroscopic hematuria cause by renal vein entrapment	We identified 187 published reports/studies that covered 736 patients, of whom 288 had microscopic hematuria and 448 had macroscopic hematuria. The patient cohort comprised 159 patients aged $\leq 17$ years. Abdominal pain was absent in approximately 65% of all patients, and a clinically relevant left-sided varicocele was observed in 29% of the male patients. A normal pre-aortic left renal vein and an anomalous anatomy were noted in 680 and 56 patients, respectively. The body mass index (BMI) was lower in patients with renal vein entrapment than in the controls, with a regression of hematuria correlating with an increase in BMI. A surgical procedure was attempted in 34% of the patients, of which the most common were endovascular stenting and transposition of the renal vein distally into the vena cava.	4
33. Fu WJ, Hong BF, Gao JP, et al. Nutcracker phenomenon: a new diagnostic method of multislice computed tomography angiography. <i>Int J Urol.</i> 2006; 13(7):870-873.	Observational-Dx	4 with nutcracker phenomenon 10 healthy controls	To evaluate the role of 3D CTA in the diagnosis of nutcracker phenomenon and its importance in postoperative follow-up.	The angles and distances between the SMA and the aorta were $39.3 \pm 4.3$ degrees and $3.1 \pm 0.2$ mm in the patient groups and $90 \pm 10$ degrees and $12 \pm 1.8$ mm in the control groups, respectively. Since 3D CTA revealed that unusual hematuria was due to compression of the LRV, it may be a useful alternative imaging technique instead of conventional examinations. The non-invasive 3D CTA may be a useful tool in the diagnosis of the nutcracker phenomenon and follow-up testing.	4
34. Mishra VC, Rowe E, Rao AR, et al. Role of i.v. urography in patients with haematuria. <i>Scand J Urol Nephrol.</i> 2004; 38(3):236-239.	Observational-Dx	1211 patients	Retrospective study to evaluate the impact of the omission of i.v. urography (IVU) on the diagnosis of renal tract malignancies and other non-malignant but significant conditions. Diagnostic yields of IVU and US were compared.	US combined with a MAG III renogram could be considered as a first-line investigation instead of IVU. This is likely to result in maximum detection of malignant and non-malignant conditions, while reducing the radiation exposure to the patient.	4

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35. Fitoz S, Ekim M, Ozcakar ZB, Elhan AH, Yalcinkaya F. Nutcracker syndrome in children: the role of upright position examination and superior mesenteric artery angle measurement in the diagnosis. <i>J Ultrasound Med.</i> 2007; 26(5):573-580.	Observational-Dx	49 patients	To evaluate the pathophysiology characteristics of nutcracker syndrome and to assess the role of upright position imaging and SMA angle measurement in the diagnosis.	The SMA angle measurement had sensitivity and specificity of 69.6% and 61.5%, respectively, in the supine position and 87.0% and 76.9% in the upright position when the cutoff values were set to less than 41 degrees and 21 degrees, respectively.	4
36. Hogg RJ, Silva FG, Berry PL, Wenz JE. Glomerular lesions in adolescents with gross hematuria or the nephrotic syndrome. Report of the Southwest Pediatric Nephrology Study Group. <i>Pediatr Nephrol.</i> 1993; 7(1):27-31.	Observational-Dx	121 patients	Retrospective study to define the specific glomerular lesions in adolescents with gross hematuria or idiopathic nephrotic syndrome.	IgA nephropathy is the most frequent findings on renal biopsy in adolescents with gross hematuria.	3
37. Shin JI, Park JM, Lee JS, Kim MJ. Doppler ultrasonographic indices in diagnosing nutcracker syndrome in children. <i>Pediatr Nephrol.</i> 2007; 22(3):409-413.	Observational-Dx	30 patients	Analysis of Doppler spectral findings to explain the Doppler US cut-off value of nutcracker syndrome causing hematuria in children.	When the cut-off values for nutcracker syndrome was set at the mean $\pm$ 2 SD (mean: 2.95 $\pm$ 0.92, range: 1.60-5.02) of 30 controls (normal children and relieved nutcracker without hematuria), the calculated cut-off value was 4.8, and the sensitivity and specificity were 100% and 93%, respectively.	4
38. Shin JI, Park JM, Lee SM, et al. Factors affecting spontaneous resolution of hematuria in childhood nutcracker syndrome. <i>Pediatr Nephrol.</i> 2005; 20(5):609-613.	Observational-Dx	20 patients	Retrospective analysis of patients to identify factors affecting spontaneous resolution of hematuria in children with nutcracker syndrome.	The PV ratios of the LRV at the follow-up US decreased significantly when compared to the first US examination (7.74 $\pm$ 2.64 vs 3.50 $\pm$ 1.09, $p$ <0.0001), and height (147.4 $\pm$ 20.1 vs 152.3 $\pm$ 18.8 cm) and weight (36.1 $\pm$ 10.9 vs 42.3 $\pm$ 12.7 kg) increased ( $p$ <0.0001). Changes in the PV ratios of the LRV correlated positively with changes in the PV at the aortomesenteric portion ( $r$ =0.569, $p$ =0.009). Changes in the PV at the aortomesenteric portion correlated negatively with changes in body mass index (BMI) ( $r$ =-0.543, $p$ =0.013).	4

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39. Alarcon CM, Cubillana PL, Aleman AC, Avellaneda EC. Hematuria secondary to congenital arteriovenous fistula treated with embolization. Arch Esp Urol. 2011; 64(6):550-553.	Review/Other-Dx	1 case	To report a rare case of hematuria caused by an arteriovenous fistula which may be a urological emergency.	No results stated	4
40. Ashley RA, Figueroa TE. Gross hematuria in a 3-year-old girl caused by a large isolated bladder hemangioma. Urology. 2010; 76(4):952-954.	Review/Other-Dx	1 case	To report a case of an isolated bladder hemangioma identified in a 3-year-old girl presenting with recurrent high-volume gross hematuria	No results stated	4
41. Ben Abdallah Chabchoub R, Chabchoub K, Maaloul I, et al. [Nutcracker syndrome: a rare cause of hematuria]. Arch Pediatr. 2011; 18(11):1188-1190.	Review/Other-Dx	2 cases	To report the case of a 4-year-old child who presented nutcracker syndrome confirmed by CT angiography of the abdomen after excluding the other causes of hematuria.	No results stated	4

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<p>42. Polito C, La Manna A, Signoriello G, Marte A. Recurrent abdominal pain in childhood urolithiasis. <i>Pediatrics</i>. 2009; 124(6):e1088-1094.</p>	<p>Observational-Dx</p>	<p>100 consecutive patients 250 controls</p>	<p>To establish the clinical presentation and features of pain attacks in children with recurrent abdominal pain (RAP) and urolithiasis.</p>	<p>Fifty-three patients had no history of dysuria or gross hematuria, and only 35 had hematuria at the first visit; 41 patients were evaluated for urolithiasis only because of a family history of kidney stones associated with RAP. Twenty-nine patients had been previously hospitalized for abdominal symptoms. Sixteen patients and 4 control subjects (1.5%) had undergone a previous appendectomy (<math>P &lt; .0001</math>). Two to 28 months before the diagnosis of urolithiasis, 37 patients underwent abdominal ultrasonography, which did not show urinary stones. Sixty-nine percent of subjects younger than 8 years of age had central/diffuse abdominal pain. The mean frequency of pain attacks was 4 to 9 times lower than in patients with functional or organic gastrointestinal RAP. Because of the inconstant occurrence of dysuria and hematuria, the location of pain in areas other than the flank, and the lack of calculi shown on imaging studies performed after pain attacks, the urologic origin of pain may be overlooked and ineffective procedures performed. The possibility of urolithiasis should be considered in children with RAP who have a family history of urolithiasis and/or infrequent pain attacks, even when dysuria and hematuria are lacking, and in younger children even when pain is not lateral.</p>	<p>3</p>

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43. Persaud AC, Stevenson MD, McMahon DR, Christopher NC. Pediatric urolithiasis: clinical predictors in the emergency department. <i>Pediatrics</i> . 2009; 124(3):888-894.	Review/Other-Dx	339 patients	To identify factors that predict the presence of urolithiasis detected with unenhanced computed tomography (UCT) in children.	Fifty-seven stones (51.8%) were ureteral, 26 (23.6%) were renal, and 4 (3.6%) were in the bladder. Among children who did not have a stone identified through UCT, 23 cases (10%) of potentially significant, alternative diagnoses were identified. A history of urolithiasis, a history of nausea and vomiting, the presence of flank pain on examination, and >2 red blood cells per high-power field in urine microscopy were positively associated with urolithiasis. A history of fever or dysuria and costovertebral angle tenderness on physical examination were inversely associated with urolithiasis on UCT scans. CONCLUSIONS: UCT plays an important role in the diagnostic evaluation of children with flank pain. Approximately 15% of children with urolithiasis do not have hematuria.	4
44. Strouse PJ, Bates DG, Bloom DA, Goodsitt MM. Non-contrast thin-section helical CT of urinary tract calculi in children. <i>Pediatr Radiol</i> . 2002; 32(5):326-332.	Observational-Dx	113 children (137 CT exams)	To determine if non-contrast thin section helical CT is useful for the diagnosis of urinary tract calculi in children. Radiology databases at three pediatric institutions were searched to identify all pediatric patients evaluated by “renal stone” protocol CT scans.	CT is a useful method to diagnose urinary tract calculi in children. Radiation dose in this retrospective study may exceed the lowest possible radiation dose for diagnostic accuracy.	4

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Alpay H, Ozen A, Gokce I, Biyikli N. Clinical and metabolic features of urolithiasis and microlithiasis in children. <i>Pediatr Nephrol.</i> 2009; 24(11):2203-2209.	Observational-Dx	162 children	To evaluate the clinical, radiological and metabolic features of children with urolithiasis or microlithiasis	The most frequently involved site was in the kidneys (86%). Ureters and bladder were involved in 12 and 2% of the cases, respectively. A family history of urolithiasis, presenting symptoms and underlying metabolic abnormalities were similar for microlithiasis and the patients with larger stones. However, in our study population, microlithiasis was mainly a disease of young infants, with a greater chance for remission and often not associated with structural changes. The presenting symptoms of urolithiasis show a wide spectrum, so that a high index of suspicion is important for early detection. A metabolic abnormality can be identified in 87% of cases of urolithiasis. Detection of microlithiasis may explain a number of symptoms, thus reducing invasive diagnostic procedures and allowing early recognition of metabolic abnormalities. These results draw attention to the importance of screening for UTIs in patients with urolithiasis.	4
46. Cochat P, Pichault V, Bacchetta J, et al. Nephrolithiasis related to inborn metabolic diseases. <i>Pediatr Nephrol.</i> 2010; 25(3):415-424.	Review/Other-Dx	N/A	To review nephrolithiasis related to inborn metabolic diseases.	Nephrolithiasis related to inherited metabolic diseases is a very rare condition that may require specific measures. However, the overall outcome usually depends on extrarenal involvement in relation to the metabolic defect.	4
47. Levine JA, Neitlich J, Verga M, Dalrymple N, Smith RC. Ureteral calculi in patients with flank pain: correlation of plain radiography with unenhanced helical CT. <i>Radiology</i> 1997; 204(1):27-31.	Observational-Dx	178 patients	To compare retrospectively the accuracy of radiographs for ureteral calculi using CT as a gold standard.	For detection of ureteral calculi: Original reading (before the patient underwent CT) was 45% for sensitivity and 77% for specificity. Blinded reading was 59% for sensitivity and 71% for specificity. Unblinded reading was 59% sensitivity (95%, CI: 47%-70%).	2



**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Oner S, Oto A, Tekgul S, et al. Comparison of spiral CT and US in the evaluation of pediatric urolithiasis. <i>Jbr-Btr.</i> 2004; 87(5):219-223.	Observational-Dx	29 infants	To determine the value of spiral CT in detecting pediatric urolithiasis and compare its value with US.	Spiral CT detected 57 stones (45 renal and 12 ureteral). US detected 34 stones (59.6%) in 18 (78.2%) patients. US localized 31 stones (68.8%) in 21 kidneys (75%) and 3 stones (25%) in 11 ureters (27.2%). Spiral CT is very effective in the diagnosis of pediatric urolithiasis and is more efficient than US in imaging pediatric patients with symptoms and signs of urolithiasis, when KUB is inconclusive.	3
49. Palmer JS, Donaher ER, O'Riordan MA, Dell KM. Diagnosis of pediatric urolithiasis: role of ultrasound and computerized tomography. <i>J Urol.</i> 2005; 174(4 Pt 1):1413-1416.	Observational-Dx	75 patients	Retrospective review of children's (ages 0 to 18 years) charts to describe the presenting features and radiographic evaluation of pediatric urolithiasis, and to determine the accuracy of US and unenhanced CT in detecting urolithiasis.	39 CT: accurate in detecting calculi in children with urolithiasis symptoms (96%-100%) and in those without symptoms (100%). 36 US: more variable accuracy in children with urolithiasis symptoms (33%-100%) vs those without symptoms (89%). US failed to detect urolithiasis in 41% of the patients with urolithiasis symptoms, compared to 5% with CT. CT was highly accurate regardless of calculus location (89%-100%), whereas US was again more variable (kidney 90%, kidney and ureter 75%, ureter alone 38%).	3
50. O'Connor OJ, McSweeney SE, Maher MM. Imaging of hematuria. <i>Radiol Clin North Am.</i> 2008; 46(1):113-132, vii.	Review/Other-Dx	N/A	To review current status of imaging of patients suspected of having urologic causes of hematuria and role of modalities used in the evaluation of these patients. Focus on MD-CTA.	Most recent data validate use of MD-CTA in the evaluation of the urothelium for neoplasms. Future studies must concentrate on radiation dose optimization and radiation dose reduction.	4
51. Potretzke AM, Monga M. Imaging modalities for urolithiasis: impact on management. <i>Curr Opin Urol.</i> 2008; 18(2):199-204.	Review/Other-Dx	N/A	To review imaging modalities used for the diagnosis of calculi and its impact on management.	CT has become a common diagnostic modality for urolithiasis and may provide prognostic information regarding the success of specific management strategies for urolithiasis.	4

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
52. Fielding JR, Steele G, Fox LA, Heller H, Loughlin KR. Spiral computerized tomography in the evaluation of acute flank pain: a replacement for excretory urography. <i>J Urol.</i> 1997;157(6):2071-2073.	Observational-Dx	89 patients	To determine the value of noncontrast enhanced spiral computerized tomography (CT) in the evaluation of suspected renal colic.	A total of 89 patients had adequate clinical followup to assess outcome accurately. Of 55 patients with ureteral obstruction on CT 11 underwent endoscopic stone removal, while 44 were treated conservatively with stone passage documented in 39. Of the 45 patients without ureteral stones identified 38 did not pass calculi and CT provided a definite diagnosis in 14. There was 1 false-negative study. The results yielded 98% sensitivity, 100% specificity, and 100% positive and 97% negative predictive values.	3
53. Niemann T, Kollmann T, Bongartz G. Diagnostic performance of low-dose CT for the detection of urolithiasis: a meta-analysis. <i>AJR Am J Roentgenol.</i> 2008;191(2):396-401.	Meta-analysis	7 studies with 1061 patients	A meta-analysis evaluating low-dose CT (<3 mSv) for detection of urinary calculi.	Pooled sensitivity and specificity of low-dose CT for the diagnosis of urinary calculi were 0.966 and 0.949, respectively.	M
54. Poletti PA, Platon A, Rutschmann OT, Schmidlin FR, Iselin CE, Becker CD. Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. <i>AJR Am J Roentgenol.</i> 2007;188(4):927-933.	Observational-Dx	125 patients	To compare a low-dose CT protocol with standard-dose unenhanced CT in patients with suspected renal colic.	Low-dose CT has sensitivities and specificities close to those of standard-dose CT. In patients with a body mass index of <30, low-dose CT achieved 96% sensitivity and 100% specificity for the detection of indirect signs of renal colic and a sensitivity of 95% and a specificity of 97% for detecting ureteral calculi. Low-dose CT was 86% sensitive for detecting ureteral calculi <3 mm and 100% sensitive for detecting calculi >3 mm.	2
55. Smith RC, Verga M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain: value of unenhanced helical CT. <i>AJR Am J Roentgenol.</i> 1996;166(1):97-101.	Observational-Dx	210 patients	To determine the value of unenhanced CT in the diagnosis of acute flank pain.	Sensitivity of 97%, specificity of 96%, and accuracy of 97% for diagnosis of ureteral stone disease. Unenhanced CT is an accurate technique.	2

**Hematuria–Child  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
<p>56. Karmazyn B, Frush DP, Applegate KE, Maxfield C, Cohen MD, Jones RP. CT with a computer-simulated dose reduction technique for detection of pediatric nephroureterolithiasis: comparison of standard and reduced radiation doses. <i>AJR</i>. 2009; 192(1):143-149.</p>	<p>Observational-Dx</p>	<p>45 patients</p>	<p>To compare the diagnostic capabilities of standard- and reduced-dose CT in the detection of nephroureterolithiasis in children.</p>	<p>Compared with the standard tube current used for the original CT scans, there was no significant reduction (<math>p=0.37</math>) in detection of renal stones at the 80-mA setting (mean dose reduction, 67%; range, 43-81%); and at the 40-mA setting (mean dose reduction, 82%; range, 72-90%), the detection rate was significantly lower (<math>p=0.05</math>). At the 40-mA setting, there was no significant difference among the children weighing 50 kg or less (<math>p=0.4</math>). Detection of ureteral stones and hydronephrosis was not significantly different at 80 and 40 mA; however, disease frequency was low, and no definite conclusion can be made. Simulated dose reduction is a useful tool for determining diagnostic thresholds for MDCT detection of renal stones in children. Use of the 80-mA setting for all children and 40 mA for children weighing 50 kg or less does not significantly affect the diagnosis of pediatric renal stones.</p>	<p>1</p>

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
57. Kulkarni NM, Uppot RN, Eisner BH, Sahani DV. Radiation Dose Reduction at Multidetector CT with Adaptive Statistical Iterative Reconstruction for Evaluation of Urolithiasis: How Low Can We Go? <i>Radiology</i> . 2012; 265(1):158-166.	Observational-Dx	25 patients	To evaluate the performance of CT examinations at 80 and 100 kV with tube current–time products of 75–150 mA and the effect of adaptive statistical iterative reconstruction (ASIR) on CT image quality in patients with urinary stone disease.	Modified-protocol filtered back projection (FBP) images showed low image quality (score, 2.5), with improvement on modified-protocol ASIR images (score, 3.4) (P = .03). All 33 stones (mean diameter, 6.1 mm; range, 2–28 mm) at modified-protocol CT were diagnosed by both readers. In 20 of 25 patients (80%), ASIR images were rated adequate for rendering other diagnoses in the abdomen (score, 2.0), as opposed to FBP images (score, 1.3). Mean radiation dose for modified-protocol CT was 1.8 mGy (1.3 mGy for patients < 200 lb; 2.3 mGy for patients > 200 lb) in comparison with 9.9 mGy for reference-protocol CT (P = .001). Image quality improvements with ASIR at reduced radiation dose of 1.8 mGy enabled effective evaluation of urinary calculi without substantially affecting diagnostic confidence.	3
58. Dunmire B, Harper JD, Cunitz BW, et al. Use of the Acoustic Shadow Width to Determine Kidney Stone Size with Ultrasound. <i>J Urol</i> . 2016;195(1):171-177.	Observational-Dx	45 kidney stones	To explore measuring the acoustic shadow behind kidney stones combined with different ultrasound imaging modalities to improve stone sizing accuracy.	Average error between the measured and true stone width was 1.4 +/- 0.8 mm, 1.7 +/- 0.9 mm, 0.9 +/- 0.8 mm for ray line, spatial compound and harmonic imaging, respectively. Average error between the shadow width and true stone width was 0.2 +/- 0.7 mm, 0.4 +/- 0.7 mm and 0.0 +/- 0.8 mm for ray line, spatial compound and harmonic imaging, respectively. Sizing error based on the stone width worsened with greater depth (p <0.001) while the sizing error based on the shadow width was independent of depth.	2

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
59. Lee JY, Kim SH, Cho JY, Han D. Color and power Doppler twinkling artifacts from urinary stones: clinical observations and phantom studies. <i>AJR</i> . 2001; 176(6):1441-1445.	Observational-Dx	32 patients	Prospective study to determine how often urinary stones show twinkling artifacts on Doppler US. Gray-scale images and color, power, and spectral Doppler images were obtained in all patients.	30/36 (83%) urinary stones showed color and power Doppler twinkling artifacts. 22/30 stones with the twinkling artifacts showed strong intensity artifacts. Spectra with saturated amplitude were obtained from all 30 stones showing color Doppler artifacts. Color Doppler twinkling artifacts may be useful in determining the presence of urinary stones.	3
60. Turrin A, Minola P, Costa F, Cerati L, Andrulli S, Trinchieri A. Diagnostic value of colour Doppler twinkling artefact in sites negative for stones on B mode renal sonography. <i>Urol Res</i> . 2007; 35(6):313-317.	Observational-Dx	67 patients with urinary stone 67 control	To determine the diagnostic value of color Doppler twinkling artifact in sites negative for stones on B-mode renal US.	Twinkling artifact was frequent in patients with stone disease (95.5%) compared to controls (9.0%) (P<0.001). Twinkling artifact was highly associated to renal stone disease and present in renal areas where a stone was undetected with B-mode approach suggesting its diagnostic role although further studies are needed to confirm its accuracy.	3
61. Shabana W, Bude RO, Rubin JM. Comparison between color Doppler twinkling artifact and acoustic shadowing for renal calculus detection: an in vitro study. <i>Ultrasound Med Biol</i> . 2009; 35(2):339-350.	Review/Other-Dx	7 uric acid calculi	To assess the ability of the color Doppler twinkling artifact to detect renal stones relative to acoustic shadowing	The contrast-to-noise ratios for twinkling were significantly higher than for acoustic shadowing. On average, twinkling produced 19.2 dB greater contrast-to-noise ratios for stones in the phantom and 17.6 dB more for the stones in the kidneys. In addition, ANOVA showed that twinkling is resistant to focusing and scanning frequency differences. The results suggest that the twinkling artifact is a robust method for detecting the presence of renal calculi. The color signature is easier to detect than is acoustic shadowing. Twinkling may be relatively resistant to many of the problems that plague US examinations for renal stones, i.e., out-of-focus scans that might be caused by beam aberration effects due to patient body habitus.	4

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
62. Dillman JR, Kappil M, Weadock WJ, et al. Sonographic twinkling artifact for renal calculus detection: correlation with CT. <i>Radiology</i> . 2011; 259(3):911-916.	Observational-Dx	1,828 US reports	To retrospectively correlate sonographic color Doppler twinkling artifact within the kidneys with unenhanced computed tomography (CT) in the detection of nephrolithiasis.	The presence of sonographic renal twinkling artifact, in general, had a 78% (95% confidence interval: 0.66, 0.90) positive predictive value for nephrolithiasis anywhere in the kidneys at CT. The true-positive rate of twinkling artifact for confirmed calculi at CT was 49% (73 of 148 twinkling foci), while the false-positive rate was 51% (75 of 148 twinkling foci). The overall sensitivity of twinkling artifact for the detection of specific individual renal calculi observed at CT was 55% (95% confidence interval: 0.47, 0.64). While renal twinkling artifact is commonly associated with nephrolithiasis, this finding is relatively insensitive in routine clinical practice and has a high false-positive rate when 5-mm unenhanced CT images are used as the reference standard.	3
63. Masch WR, Cohan RH, Ellis JH, Dillman JR, Rubin JM, Davenport MS. Clinical Effectiveness of Prospectively Reported Sonographic Twinkling Artifact for the Diagnosis of Renal Calculus in Patients Without Known Urolithiasis. <i>AJR Am J Roentgenol</i> . 2016;206(2):326-331.	Observational-Dx	85 patients	To determine the clinical effectiveness of prospectively reported sonographic twinkling artifact for the diagnosis of renal calculus in patients without known urolithiasis.	Eighty-five patients formed the study population. Isolated sonographic twinkling artifact had sensitivity of 0.78 (82/105), specificity of 0.40 (26/65), and a positive likelihood ratio of 1.30 for the diagnosis of renal calculus. Specificity and positive likelihood ratio improved and sensitivity declined when the following additional diagnostic features were present: sonographic twinkling artifact and echogenic focus (sensitivity, 0.61 [64/105]; specificity, 0.65 [42/65]; positive likelihood ratio, 1.72); sonographic twinkling artifact and posterior acoustic shadowing (sensitivity, 0.31 [33/105]; specificity, 0.95 [62/65]; positive likelihood ratio, 6.81); all three features (sensitivity, 0.31 [33/105]; specificity, 0.95 [62/65]; positive likelihood ratio, 6.81).	2

**Hematuria–Child  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
64. Johnson EK, Faerber GJ, Roberts WW, et al. Are stone protocol computed tomography scans mandatory for children with suspected urinary calculi? <i>Urology</i> . 2011; 78(3):662-666.	Observational-Dx	42 patients	To examine the clinical utility of noncontrast-enhanced computed tomography (NCCT) in pediatric patients with urolithiasis who progressed to surgery. Although NCCT is routine for the evaluation of adult patients with suspected urolithiasis, its routine use in the pediatric population is tempered by concern about radiation exposure.	A discernible risk factor or cause of urolithiasis was absent in 21 patients (47%). A review of imaging studies found 38 with stones visible on ultrasonography and/or abdominal plain film. A total of 21 patients underwent NCCT, in addition to ultrasonography and/or abdominal plain film. Of these, only 5 patients required NCCT for the diagnosis or management of their stone. Nearly 90% of pediatric patients treated for symptomatic urolithiasis could have completed their evaluation and treatment without undergoing NCCT. For children who present with signs and symptoms suggesting urinary calculi, an initial evaluation and imaging with ultrasonography and abdominal plain film might suffice, avoiding the radiation of NCCT.	4
65. McAleer IM, Kaplan GW. Pediatric genitourinary trauma. <i>Urol Clin North Am</i> . 1995; 22(1):177-188.	Review/Other-Dx	N/A	To review GU trauma in children.	CT is the preferred diagnostic imaging modality. Cystography and urethrography are essential in diagnosing bladder and ureteral injuries.	4
66. Stalker HP, Kaufman RA, Stedje K. The significance of hematuria in children after blunt abdominal trauma. <i>AJR</i> . 1990; 154(3):569-571.	Review/Other-Dx	256 patient records	To review and analyze medical records and CT examinations of children to assess the significance of hematuria after blunt abdominal trauma.	Direct relationship between the amount of hematuria and the severity of renal injury. No normotensive child with fewer than 50 red blood cells (RBC) per high-power field had a significant renal injury, and conversely, all children with significant renal injuries had either large amounts of hematuria or shock.	4

**Hematuria–Child  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
67. Brown SL, Haas C, Dinchman KH, Elder JS, Spirnak JP. Radiologic evaluation of pediatric blunt renal trauma in patients with microscopic hematuria. <i>World J Surg.</i> 2001; 25(12):1557-1560.	Review/Other-Dx	1200 patient records	Retrospective review of medical records to determine if radiographic evaluation is required in children with microscopic hematuria and blunt renal trauma.	65 patients had microscopic hematuria. 3/65 had significant renal injury while 32 had normal findings. The degree of hematuria did not correlate with the grade of renal injury. Pediatric patients with blunt trauma, microscopic hematuria, and no associated injuries do not require radiologic evaluation, as significant renal injuries are unlikely, but children with associated injuries and microscopic hematuria after blunt trauma may have significant renal injuries and should undergo radiologic evaluation.	4
68. Chopra P, St-Vil D, Yazbeck S. Blunt renal trauma-blessing in disguise? <i>J Pediatr Surg.</i> 2002; 37(5):779-782.	Review/Other-Dx	103 patients	Retrospective review of medical records to quantify pathologic lesions of the kidney found incidentally during the workup of a blunt renal trauma. Patients had US, Doppler of renal vessels. CT, cystography, or nuclear medicine functional studies were performed as indicated.	Coexisting urogenital lesions were identified in 13/103 (12.6%). Stenosis of the uretero-pelvic junction was the most frequent diagnosis (n=7): 3 patients required uretero-pyeloplasty, and 3 required nephrectomy. 2 heterogeneous renal masses were discovered; elective resection and open biopsy were performed. The diagnoses of multicystic kidney and solitary cyst with complex hematoma, respectively, were confirmed on pathology.	4
69. Levy JB, Baskin LS, Ewalt DH, et al. Nonoperative management of blunt pediatric major renal trauma. <i>Urology.</i> 1993; 42(4):418-424.	Review/Other-Dx	61 patients	Retrospective review to determine which patients with blunt renal trauma and hematuria required imaging, and the best way of managing major renal injuries.	Gross hematuria (n=10) was a significant predictor of major renal injury (n=5) (p<0.001). All 3 patients with microscopic hematuria and a major renal injury also had evidence of multisystem trauma. Admission blood pressure, hemoglobin, and trauma score were not predictors of major renal trauma.	4



**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
70. Morey AF, Bruce JE, McAninch JW. Efficacy of radiographic imaging in pediatric blunt renal trauma. <i>J Urol.</i> 1996; 156(6):2014-2018.	Review/Ot her-Dx	180 patient records	Review records to determine the accuracy of radiographic imaging in detecting renal injuries in children with blunt trauma with no significant hematuria.	Of 33 patients with gross hematuria, renal injuries were found in 9, including 3 who required immediate surgical repair of a major renal laceration or vascular injury. Combining results with other reported series showed significant renal injuries in 11/548 children (2%) with less than 50 RBC per high power field on presenting urinalysis after blunt abdominal trauma.	4
71. Nguyen MM, Das S. Pediatric renal trauma. <i>Urology.</i> 2002; 59(5):762-766; discussion 766-767.	Review/Ot her-Dx	61 patients	Analyze medical records to determine the appropriate indications for imaging and operative intervention in pediatric renal trauma.	To make the decision for renal imaging for the diagnosis and grading of renal injuries, clinical status, history, injury mechanism must be considered in addition to urinalysis.	4
72. Santucci RA, Langenburg SE, Zachareas MJ. Traumatic hematuria in children can be evaluated as in adults. <i>J Urol.</i> 2004; 171(2 Pt 1):822-825.	Review/Ot her-Dx	720 patients	Retrospective review to evaluate whether the criteria for imaging the renal parenchyma in adult blunt trauma victims apply to the pediatric population.	334/720 patients had imaging and 59 renal injuries were identified. It is appropriate to image pediatric trauma cases based on the adult criteria of gross hematuria, shock and significant deceleration injury.	4
73. Nance ML, Lutz N, Carr MC, Canning DA, Stafford PW. Blunt renal injuries in children can be managed nonoperatively: outcome in a consecutive series of patients. <i>J Trauma.</i> 2004; 57(3):474-478; discussion 478.	Review/Ot her-Dx	101 patients	Review management and outcome data of consecutive series of children with blunt renal injury to determine whether pediatric renal injuries can be managed nonoperatively.	Nonoperative management strategy was useful and successful in pediatric blunt renal injuries (94.7% successful nonoperative rate, 98.9% renal salvage rate). Adjunctive urologic procedures (eg, ureteral stenting) were useful in selected cases.	4
74. Taylor GA, Eichelberger MR, Potter BM. Hematuria. A marker of abdominal injury in children after blunt trauma. <i>Ann Surg.</i> 1988; 208(6):688-693.	Review/Ot her-Dx	378 patients	To examine the significance of hematuria in children with blunt abdominal trauma in order to define its diagnostic role and outline a rationale for use of CT.	Asymptomatic hematuria is a low-yield indication for abdominal CT. When in association with other suggestive clinical signs and symptoms, the presence and severity of hematuria can be useful markers of underlying abdominal injury.	4
75. Perez-Brayfield MR, Gatti JM, Smith EA, et al. Blunt traumatic hematuria in children. Is a simplified algorithm justified? <i>J Urol.</i> 2002; 167(6):2543-2546; discussion 2546-2547.	Review/Ot her-Dx	110 patients	Retrospective review to determine if radiographic evaluation is indicated in all children with traumatic hematuria.	Radiological evaluation (abdominal and pelvic CT) should be performed only in patients with =50 RBC on urinalysis, hypotension at presentation to the emergency room or based on the severity of mechanism of injury.	4

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
76. Abou-Jaoude WA, Sugarman JM, Fallat ME, Casale AJ. Indicators of genitourinary tract injury or anomaly in cases of pediatric blunt trauma. <i>J Pediatr Surg.</i> 1996; 31(1):86-89; discussion 90.	Observational-Dx	100 patients	Retrospective review: To determine whether a certain threshold of microscopic hematuria was associated with GU tract injury, and to identify additional factors warranting evaluation of the GU. All but one study patient had an intravenous pyelogram and/or CT.	A threshold of $\geq 20$ RBCs/HPF as an indication for radiographic evaluation would have missed 28% of cases with GU tract injuries or occult anomalies. Pelvic fractures and abdominal/chest injuries help to identify patients who require evaluation of the GU tract.	4
77. Thorp AW, Young TP, Brown L. Test characteristics of urinalysis to predict urologic injury in children. <i>West J Emerg Med.</i> 2011;12(2):168-172.	Observational-Dx	502 children	To use receiver operator characteristic curve methodology to determine the test characteristics of microscopic hematuria for identifying urologic injuries in children who underwent computed tomography (CT) of the abdomen and pelvis as part of a trauma evaluation.	Of the 502 children in the study group, 17 (3%; 95% CI [2%-5.4%]) had evidence of urologic injury on the abdominal or pelvic CT. Microscopic urinalysis for those children with urologic injury ranged from 0 to 15,544 RBC/hpf. The remaining 485 children without urologic injury had a range of hematuria from 0 to 20,596 RBC/hpf. A receiver operating characteristic curve was generated and the area under the curve is 0.796 (95% CI [0.666-0.925]).	3
78. Rathaus V, Pomeranz A, Shapiro-Feinberg M, Zissin R. Isolated severe renal injuries after minimal blunt trauma to the upper abdomen and flank: CT findings. <i>Emerg Radiol.</i> 2004; 10(4):190-192.	Review/Other-Dx	6 patients	To describe renal injuries in patients with major isolated renal injuries resulting from minimal blunt trauma to the upper abdomen and/or the flank.	Major kidney insult can occur after a minimal blunt trauma localized to the flank or upper abdomen. Abdominal CT is recommended when clinical findings suggest renal injury.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
79. Raz O, Haifler M, Copel L, et al. Use of adult criteria for slice imaging may limit unnecessary radiation exposure in children presenting with hematuria and blunt abdominal trauma. <i>Urology</i> . 2011; 77(1):187-190.	Observational-Dx	46 consecutive patients	To examine whether it would be safe to use adult criteria for imaging in pediatric blunt renal trauma and hematuria.	The performance of the macro-microhematuria distinction in the prediction of renal injury on CT scan is relatively poor: sensitivity 59%, specificity 14%, positive predictive value (PPV) 84%, and negative predictive value (NPV) 62%, whereas the performance of macrohematuria criteria in the prediction of renal-relevant injury is sensitivity 100%, specificity 61%, PPV 18%, and NPV 93%. The yield of abdominal CT in pediatric renal trauma is low in patients presenting with microhematuria. Our data suggest that it may be possible that adult criteria for renal imaging are sufficient for children with abdominal blunt trauma and microhematuria. Adopting such strategy will result in substantial reduction in exposure to radiation, supposedly without increasing the patient's risk.	3
80. Smith JK, Kenney PJ. Imaging of renal trauma. [Review] [58 refs]. <i>Radiol Clin North Am</i> . 41(5):1019-35, 2003 Sep.	Review/Other-Dx	N/A	To review role of CT in the imaging of renal trauma.	CT is recommended for patients with penetrating trauma and hematuria, blunt trauma with shock and hematuria, or gross hematuria.	4
81. Morgan DE, Nallamala LK, Kenney PJ, Mayo MS, Rue LW, 3rd. CT cystography: radiographic and clinical predictors of bladder rupture. <i>AJR</i> . 2000; 174(1):89-95.	Observational-Dx	157 patients	To prospectively evaluate clinical and radiographic variables that correlated with positive findings on CT cystography. The variables are then used as selection criteria for CT cystography in trauma patients.	Of 157 patients, 12 had bladder rupture. One or more pelvic fractures were present in 9/12 patients (75%) (p<0.001). 8/12 (67%) patients had gross hematuria (p<0.001). No ruptures were seen in patients with <25 RBC/HPF (RBC per high-power field). All patients with rupture had pelvic fluid revealed on standard contrast-enhanced CT (p<0.001). Gross hematuria, pelvic fluid, and specific pelvic fractures were highly correlated with bladder rupture; identification of these findings may help in selection of trauma patients for CT cystography.	3

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
82. Peng MY, Parisky YR, Cornwell EE, 3rd, Radin R, Bragin S. CT cystography versus conventional cystography in evaluation of bladder injury. <i>AJR</i> . 1999; 173(5):1269-1272.	Observational-Dx	55 patients	To prospectively compare CT cystography with conventional cystography to identify bladder injury in patients with hematuria after blunt abdominal trauma.	50/55 (91%) patients did not show bladder injury on either CT cystography or conventional cystography. 33/50 patients had intraperitoneal fluid on the initial abdominopelvic CT scan. 5/55 (9%) patients had bladder rupture on CT cystography. CT cystography is an accurate method for evaluating bladder injury in the blunt abdominal trauma victim with hematuria.	3
83. Sivit CJ, Cutting JP, Eichelberger MR. CT diagnosis and localization of rupture of the bladder in children with blunt abdominal trauma: significance of contrast material extravasation in the pelvis. <i>AJR</i> . 1995; 164(5):1243-1246.	Observational-Dx	1500	Prospectively evaluate CT scans of children with blunt trauma to determine the value of CT in showing extravasation of IV contrast material as a means of detecting and localizing bladder rupture.	Extravasated IV contrast material in the pelvis was noted in 7 children with bladder rupture and 2/1,493 children without bladder rupture. Location of extravasated contrast material at CT was useful in differentiating intraperitoneal from extraperitoneal one rupture.	3

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
84. Chan DP, Abujudeh HH, Cushing GL, Jr., Novelline RA. CT cystography with multiplanar reformation for suspected bladder rupture: experience in 234 cases. <i>AJR</i> . 2006; 187(5):1296-1302.	Observational-Dx	234 patients	Retrospective review was performed to determine the accuracy of CT cystography and the role of multiplanar reformation in the diagnosis of bladder injury.	From the total of 234 examinations, 216 (92.3%) were interpreted as negative and 18 examinations (7.7%) were interpreted as positive. On the 18 positive examinations, 11 were extraperitoneal bladder rupture, five were intraperitoneal bladder rupture, and two were combined intraperitoneal and extraperitoneal bladder rupture. Surgical bladder exploration and repair were performed in nine of the 18 cases. Seven (77.8%) of the nine cases had operative findings consistent with the CT cystogram findings. The overall sensitivity and specificity of CT cystography in diagnosing bladder rupture were each 100%. For extraperitoneal bladder rupture, the sensitivity and specificity were 92.8% and 100%, respectively. For intraperitoneal rupture, the sensitivity and specificity were 100% and 99%, respectively. CT cystography is accurate for diagnosing bladder rupture. Sagittal and coronal multiplanar reformations may be helpful in identifying most sites of bladder rupture.	3
85. Filiatrault D, Longpre D, Patriquin H, et al. Investigation of childhood blunt abdominal trauma: a practical approach using ultrasound as the initial diagnostic modality. <i>Pediatr Radiol</i> . 1987; 17(5):373-379.	Observational-Dx	170 patients	Retrospective study to examine childhood blunt abdominal trauma with IVU, US and scintigraphy.	US became the first line screening tool, and was combined with IVU in suspected renal trauma.	3
86. Korner M, Krotz MM, Degenhart C, Pfeifer KJ, Reiser MF, Linsenmaier U. Current Role of Emergency US in Patients with Major Trauma. <i>Radiographics</i> . 2008; 28(1):225-242.	Review/Other-Dx	N/A	To review the current role of US in patients with major trauma.	US is usually the initial imaging examination for major trauma patients, but because of its poor sensitivity for the detection of most solid organs, the initial survey with US is often performed with a FAST protocol. FAST may be used also to exclude injuries to the heart and pericardium.	4

**Hematuria–Child**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
87. Sirlin CB, Brown MA, Deutsch R, et al. Screening US for blunt abdominal trauma: objective predictors of false-negative findings and missed injuries. <i>Radiology</i> . 2003; 229(3):766-774.	Observational-Dx	3,679 patients	Retrospective study to classify patients with negative US into high-risk and low-risk categories.	High-risk patients 24 times more likely to have missed abdominal injury. Hematuria in fractures of lumbar spine and pelvis most common by high risk findings.	3
88. Mayor B, Gudinchet F, Wicky S, Reinberg O, Schnyder P. Imaging evaluation of blunt renal trauma in children: diagnostic accuracy of intravenous pyelography and ultrasonography. <i>Pediatr Radiol</i> . 1995;25(3):214-218.	Observational-Dx	46 children	To assess the diagnostic accuracy of the different methods, including ultrasonography (US), intravenous pyelography (IVP), and computed tomography (CT), and to determine the optimal radiologic management.	The diagnostic accuracy of IVP (80.8%) was superior to the diagnostic accuracy of US (41%) in all types of renal injuries.	3
89. McGahan JP, Horton S, Gerscovich EO, et al. Appearance of solid organ injury with contrast-enhanced sonography in blunt abdominal trauma: preliminary experience. <i>AJR Am J Roentgenol</i> . 187(3):658-66, 2006 Sep.	Observational-Dx	22 injuries	Prospective study to compare the detection rate of injury and differentiate imaging findings of contrast-enhanced US and non-contrast-enhanced US. Contrast-enhanced CT was used to identify hepatic, splenic, and renal injuries.	CT detected 22 injuries in 20 patients. Non-contrast-enhanced US revealed 11/22 (50%) injuries, while contrast-enhanced US depicted 20/22 (91%) injuries. The average conspicuity grade for the splenic injuries increased from 0.67 for non-contrast-enhanced US to 2.33 for contrast-enhanced US. With regard to liver injuries, the conspicuity scale increased from 1.0 for non-contrast-enhanced US to 2.2 for contrast-enhanced.	1
90. Valentino M, Serra C, Pavlica P, et al. Blunt abdominal trauma: diagnostic performance of contrast-enhanced US in children--initial experience. <i>Radiology</i> . 2008; 246(3):903-909.	Observational-Dx	27 consecutive children	To prospectively compare the sensitivity and specificity of US with those of contrast-enhanced US in detecting solid organ injuries in children with blunt abdominal trauma, with contrast-enhanced CT as the reference standard.	Contrast-enhanced US: Sensitivity 92.2%, specificity 100%, PPV 100%, NPV 93.8%. US: Sensitivity 57.1%, specificity 86.7%, PPV 80.0%, NPV 68.4%. Diagnostic performance of contrast-enhanced US was better than that of US. Contrast-enhanced US was almost as accurate as contrast-enhanced CT in depicting solid organ injuries in children.	1
91. Halachmi S, Chait P, Hodapp J, et al. Renal pseudoaneurysm after blunt renal trauma in a pediatric patient: management by angiographic embolization. <i>Urology</i> . 2003;61(1):224.	Review/Other-Dx	1 Case	To describe a rare case of renal artery pseudoaneurysm after blunt renal injury managed successfully with selective embolization.	No results listed in abstract.	4

**Hematuria–Child  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
92. Saad DF, Gow KW, Redd D, Rausbaum G, Wulkan ML. Renal artery pseudoaneurysm secondary to blunt trauma treated with microcoil embolization. <i>J Pediatr Surg.</i> 2005;40(11):e65-67.	Review/Other-Dx	1 case	To describe renal artery pseudoaneurysm secondary to blunt trauma treated with microcoil embolization.	An 11-year-old girl fell off a horse onto her right flank. She sustained multiple right hepatic lobe lacerations and a complex fracture of the upper pole of the right kidney. Her initial hospital course was uncomplicated, and she was discharged after an uneventful 6-day course. The child did well for 2 weeks, until she developed right back pain and gross hematuria. A computed tomography scan revealed a right renal artery pseudoaneurysm. Angiography confirmed the presence of a pseudoaneurysm, which was fed by a single segmental branch originating from the renal artery. The artery was successfully occluded with a single platinum microcoil, which was demonstrated by the absence of contrast flow into the pseudoaneurysm. The patient recovered and was discharged shortly after the procedure. She initially had intermittent pain and hematuria, which resolved. Follow-up computed tomography scans have shown resolution of both the renal and hepatic lesions.	4
93. Wu SR, Shakibai S, McGahan JP, Richards JR. Combined head and abdominal computed tomography for blunt trauma: which patients with minor head trauma benefit most? <i>Emerg Radiol.</i> 2006; 13(2):61-67.	Observational-Dx	1,478 patients	Retrospective review to evaluate which patients with minor head trauma benefit most from combined head and abdomen CT.	Of 1,478 patients, 18 (1%) patients had both head and abdominal injuries detected by combined CT. 112 (8%) patients had only head injuries, and 131 (9%) had only intraabdominal injuries detected. Patients with loss of consciousness and/or Glasgow coma scale of 14 frequently undergo head CT.	4

**Hematuria–Child  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
<p>94. Olthof DC, Joosse P, van der Vlies CH, de Reijke TM, Goslings JC. Routine urinalysis in patients with a blunt abdominal trauma mechanism is not valuable to detect urogenital injury. <i>Emergency Medicine Journal</i>. 32(2):119-23, 2015 Feb.</p>	<p>Review/Other-Dx</p>	<p>1815 patients</p>	<p>To investigate whether the routine performance of urinalysis in patients with a blunt trauma mechanism is still valuable.</p>	<p>A total of 1815 patients were included. The prevalence of intra-abdominal and urogenital injuries was 13% and 8%, respectively. In 1363 patients (75%), urinalysis was performed and 1031 patients (57%) underwent imaging for urogenital injury as well. The presence of macroscopic haematuria (n=16) led to clinical consequences in 73% of the patients (11 out of 15), regardless of the findings on imaging. Microscopic haematuria on urinalysis in combination with no findings on imaging led to clinical consequences in 8 out of 212 patients (4%). Microscopic haematuria on urinalysis in patients who did not have imaging for urogenital injury did not lead to clinical consequences (0 out of 54 patients; 0%). All the 8 patients who underwent an intervention had positive findings on imaging.</p>	<p>4</p>



**Hematuria–Child  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
95. Holmes JF, Mao A, Awasthi S, McGahan JP, Wisner DH, Kuppermann N. Validation of a prediction rule for the identification of children with intra-abdominal injuries after blunt torso trauma. <i>Ann Emerg Med.</i> 2009; 54(4):528-533.	Observational-Dx	1,324 patients	To validate the accuracy of a previously derived clinical prediction rule for the identification of children with intra-abdominal injuries after blunt torso trauma.	The prediction rule had the following test characteristics: sensitivity=149 of 157, 94.9% (95% confidence interval [CI] 90.2% to 97.7%) and specificity=357 of 962, 37.1% (95% CI 34.0 to 40.3%). Three hundred sixty-five patients tested negative for the rule; thus, strict application would have resulted in a 33% reduction in abdominal CT scanning. Of the 8 patients with intra-abdominal injury not identified by the prediction rule, 1 underwent a laparotomy. This patient had a serosal tear and a mesenteric hematoma at laparotomy, neither of which required specific surgical intervention. A clinical prediction rule consisting of 6 variables, easily available to clinicians in the ED, identifies most but not all children with intra-abdominal injury. Application of the prediction rule to this sample would have reduced the number of unnecessary abdominal CT scans performed but would have failed to identify 1 child undergoing (a nontherapeutic) laparotomy. Thus, further refinement of this prediction rule in a large, multicenter cohort is necessary before widespread implementation.	3
96. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <a href="https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf">https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf</a> .	Review/Other-Dx	N/A	Guidance document on exposure of patients to ionizing radiation.	No results stated in abstract.	4

## Evidence Table Key

### Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  - a. The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  - b. The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  - c. The study is an expert opinion or consensus document.
- Meta-analysis
  - a. *Good quality* – the study design, methods, analysis, and results are valid and the conclusion is supported.
  - b. *Inadequate quality* – the study design, analysis, and results lack the methodological rigor to be considered a good meta-analysis study.

## Abbreviations Key

Dx = Diagnostic

Tx = Treatment