KIDNEY STONES IN KIDS: INTERPLAY OF GENETICS AND NUTRITION

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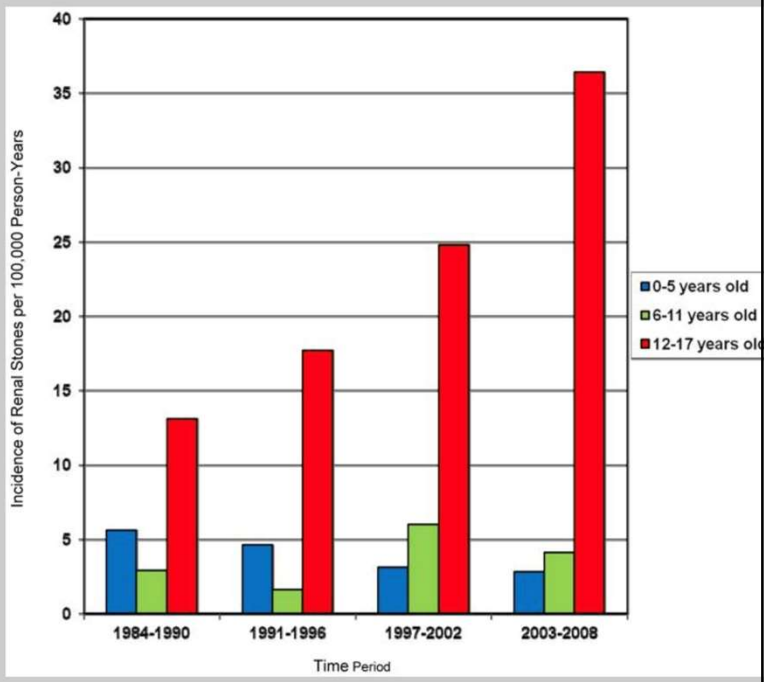
KIDNEY STONE INCIDENCE IN CHILDREN IS RISING (MN)

Sas D. Current Opin Ped 2020



KIDNEY STONE INCIDENCE IN CHILDREN IS RISING (SC)

Table 7. Adjusted estimates of group–level incidence rates of nephrolithiasis in South Carolina by age and race from 1997 to 2012: Model 6

Model 6: Age Group (yr)	5-yr Change in Kidney Stone Incidence among Whites (95% Confidence Interval)	5-yr Change in Kidney Stone Incidence among Blacks (95% Confidence Interval)	5-yr Change in Kidney Stone Incidence among Other Races (95% Confidence Interval)
<10	1.11 (0.99 to 1.24)	1.23 (0.89 to 1.69)	0.53 (0.15 to 1.93)
10–14	1.21 (1.13 to 1.29)	1.15 (0.89 to 1.50)	0.94 (0.51 to 1.72)
15–19	1.25 (1.20 to 1.28)	1.37 (1.23 to 1.52)	1.70 (1.34 to 2.16)
20–24	1.13 (1.10 to 1.15)	1.30 (1.22 to 1.38)	1.15 (1.02 to 1.31)
25–34	1.05 (1.04 to 1.07)	1.21 (1.16 to 1.26)	1.13 (1.04 to 1.21)
35–44	1.06 (1.05 to 1.07)	1.20 (1.16 to 1.25)	1.26 (1.18 to 1.36)
45–64	0.95 (0.94 to 0.96)	1.05 (1.02 to 1.07)	1.63 (1.52 to 1.73)
≥65	1.06 (1.04 to 1.07)	1.17 (0.83 to 1.65)	2.44 (1.68 to 3.53)

Model 6 included an interaction term between race, age, and year. All models with interactions additionally included each main effect, lower–order interaction terms, and a random intercept for county of residence. Models examining for race effects were adjusted for age and sex.

Tasian et al, CJASN 2016

GUT MICROBIOME?

- ANTIBIOTIC EXPOSURE ASSOCIATES WITH RISK OF KIDNEY STONES, EFFECT GREATEST IN CHILDREN
  - TASIAN ET AL JASN 2018
- GUT MICROBIAL DIVERSITY IS DIMINISHED IN CHILDREN WITH KIDNEY STONES
  - DENBURG ET AL JASN 2020

UNLIKE IN ADULTS…

- NOT LINKED TO RISE IN OBESITY

Cambareri GM et al, Urology 2017
Kieran K et al, J Urol 2010
KimSS et al, J Urol 2011

LIKE ADULTS

- INCREASED INTAKE OF PROCESSED FOOD, SODIUM
- INTAKE OF MILK SUBSTITUTED BY SUGARY DRINKS

Dunford EK et al, Pediatr Obes 2018
Keller KL et al, J Am Diet Assoc 2009
Martinez Steele E et al, BMJ Open 2016
Rajeshwari R et al, J Am Diet Assoc 2005.

KIDNEY STONES: MORE THAN A PAIN

THE UNIV
CHICAGO

COMMON CLINICAL RISK FACTORS

- HISTORY OF KIDNEY STONES
- OBESITY, DM, GOUT, HTN
- DIETARY RISK FACTORS
- ENHANCED ENTERIC OXALATE ABSORPTION

Taylor EN, et al, KI 2005
Taylor EN, et al JAMA 2005
Curhan, GC et al JASN 1998
Kramer HM, et al KI 2003

Madore F, et al. AJKD 1998
Ferraro PM, et al. JAMA 2013
Taylor EN J Urol 2016
Dhondup T, et al. AJKD 2018

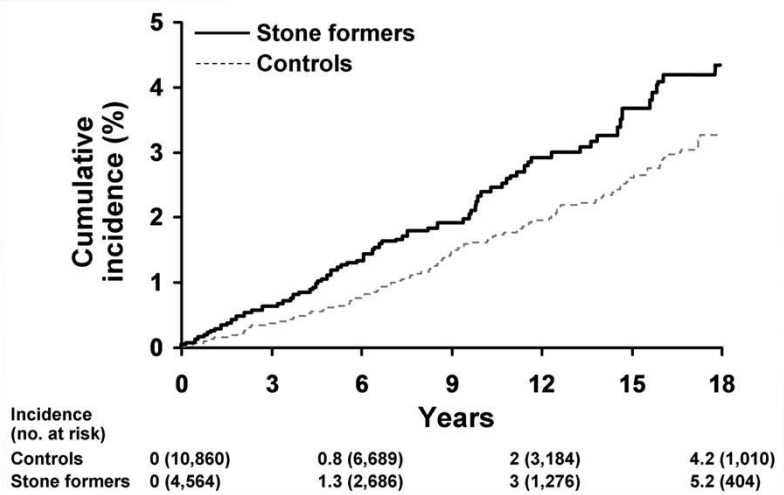
COMMON CLINICAL ASSOCIATIONS

- BONE FRACTURE, OSTEOPOROSIS
- HYPERTENSION
- CORONARY ARTERY DISEASE
- CHRONIC KIDNEY DISEASE/ESRD

Taylor EN, et al, KI 2005
Taylor EN, et al JAMA 2005
Curhan, GC et al JASN 1998
Kramer HM, et al KI 2003

Madore F, et al. AJKD 1998
Ferraro PM, et al. JAMA 2013
Taylor EN J Urol 2016
Dhondup T, et al. AJKD 2018

ASSOCIATION WITH MI

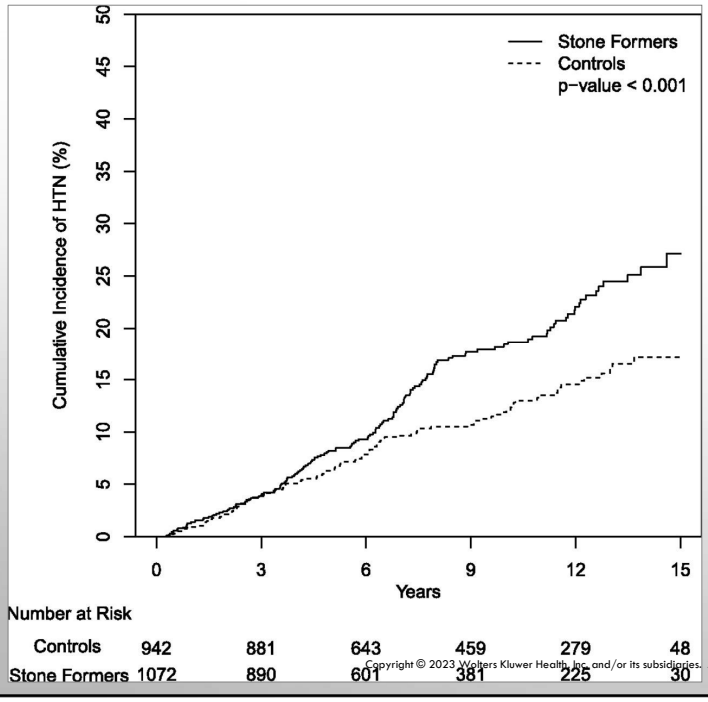


RULE AD ET AL, JASN 2010

ASSOCIATION WITH VASCULAR CALCIFICATION

- YOUNG KIDNEY STONE FORMERS WITH HIGHER PREVALENCE OF SUBCLINICAL ATHEROSCLEROSIS BASED ON INCREASED CAROTID INTIMA-MEDIA WALL THICKNESS
- HIGHER CAROTID-RADIAL AND CAROTID-FEMORAL PULSEWAVE VELOCITIES IN STONE FORMERS AND CORRELATED TO LOWER BMD T-SCORES
- KSF HAVE HIGHER AAC SCORES RELATIVE TO AGE AND SEX MATCHED CONTROLS

REINER AP, ET AL: . J UROL 2011, FABRIS A, ET AL J NEPHROL 2014, SHAVIT L, ET AL. CJASN 2015



ASSOCIATION WITH HYPERTENSION

RISK OF HYPERTENSION AMONG FIRST-TIME SYMPTOMATIC KIDNEY STONE FORMERS

KITTANAMONGKOLCHAI, WONNGARM; MARA, KRISTIN C.; MEHTA, RAMILA A.; VAUGHAN, LISA E.; DENIC, ALEKSANDAR; KNOEDLER, JOHN J.; ENDERS, FELICITY T.; LIESKE, JOHN C.; RULE, ANDREW D.

CLINICAL JOURNAL OF THE AMERICAN SOCIETY OF NEPHROLOGY12(3):476-482, MARCH 2017.

DOI: 10.2215/CJN.06600616

HIGHER RISK OF HYPERTENSION IN STONE FORMERS. THE UNADJUSTED CUMULATIVE INCIDENCE OF HYPERTENSION (HTN) AMONG INCIDENT SYMPTOMATIC STONE FORMERS COMPARED WITH AGE- AND SEX-MATCHED CONTROLS.

12

ASSOCIATION WITH BONE HEALTH

- 1 IN 4 PATIENTS DIA[illegible]N (MEAN AGE 64, 83% MEN) HAD HX OF FR[illegible]
- OF THOSE WITHOU[illegible]
  - 12.2% HAD A DI[illegible]
  - 9.1% UNDERWEN[illegible]
- DXA MUCH MORE LI[illegible]CRINOLOGY, OR NEPHROLOGY

GANESAN ET AL. OSTEOPOROSIS, FRACTURES, AND BONE MINERAL DENSITY SCREENING IN VETERANS WITH KIDNEY STONE DISEASE. JBMR 2021

NOT JUST ADULTS!

- TEENS AGED 12-17 WITH HISTORY OF STONES HAD HIGHER CAROTID INTIMAL THICKNESS THAN CONTROL TEENS
- ATHEROSCLEROSIS RELATED MARKERS FIBRONECTIN 1, VCAM1, AND OTHERS WERE HIGHER IN THE URINE OF STONE FORMING TEENS THAN CONTROLS

Kusumi et al, J Peds 2015

FAMILY HISTORY AND STONES

- CURHAN, ET. AL. JASN 1997 - HPFS
  - MEN WITH KIDNEY STONES WERE 3 TIMES MORE LIKELY TO HAVE A FH OF STONES THAN NON-STONE FORMERS
  - MEN WITH A FH OF STONES WERE ALMOST 3 TIMES MORE LIKELY TO FORM A FIRST STONE OVER 8 YEARS OF FOLLOW-UP
- GOLDFARB, ET. AL. KI 2005 – VET REGISTRY
  - MONOZYGOTIC TWINS HAD A 32% CONCORDANCE RATE FOR STONES, COMPARED WITH 17% FOR DIZYGOTIC TWINS
- THE FAMILIAL CLUSTERING INDEX FOR STONES IN MALE SIBLINGS IS 2.5-4, COMPARED WITH AN INDEX OF 2 FOR TYPE 2 DM OR HTN

MONOGENIC ASSOCIATIONS WITH STONES

Chul Koo, et al. Asian J Urol 2022

Table 1 Monogenic disorders of urolithiasis.

Disorder	Gene	Inheritance	Phenotype
Autosomal dominant idiopathic hypercalciuria	• *ADCY10* and *VDR*	AD	• Normocalcemia and normal PTH
Autosomal dominant hypocalcemia with hypercalciuria	• *CASR* and *GNA11*	AD	• Hypocalcemia, hyperphosphatemia, hypomagnesemia, and low to normal range PTH
Bartter syndrome			
Type I	• *NKCC2 (SLC12A1)*	AR	• Antenatal or postnatal nephrocalcinosis, hypokalemia, and metabolic alkalosis
Type II	• *ROMK (KCNJ1)*	AR	• Antenatal/postnatal nephrocalcinosis, hyperkalemia in infancy, postnatal hypokalemia, late-onset nephrocalcinosis, and CKD
Type III	• *CLCNKB*	AR	• Hypokalemic metabolic alkalosis, nephrocalcinosis, and late-onset symptoms
Type IVa	• *BSND*	AR	• Sensorineural hearing loss and early-onset CKD
Type IVb	• *CLCNKB* and *CLCNKA*	AR	• Renal salt wasting and sensorineural hearing loss
Type V	• *MAGED2*	XLR	• Salt wasting, polyuria, hypokalemia, nephrocalcinosis, and antenatal onset
Dent disease			
Type 1	• *CLCN5*	XLR	• LMW proteinuria, nephrocalcinosis, and CKD with progression to ESRD
Type 2	• *OCRL*	XLR	• LMW proteinuria and nephrocalcinosis (less frequent than type 1)
Hereditary hypophosphatemic rickets with hypercalciuria	• *SLC34A1*, *SLC34A3*, and *SLC9A3R1*	AR	• Low serum phosphate, hypophosphatemia, normocalcemia, and elevated $1,25(OH)_2$ vitamin D
Familial hypomagnesemia with hypercalciuria and nephrocalcinosis	• *CLDN16* and *CLDN19*	AR	• Hypomagnesemia, nephrocalcinosis, and progression to ESRD in adolescence
Distal renal tubular acidosis	• *ATP6V1B1*, *ATP6V0A4*, and *SLC4A1*	AD	• Hypokalemia, metabolic acidosis, nephrocalcinosis, growth delay, early-onset sensorineural deafness, and metabolic bone disease
Primary hyperoxaluria	• *AGXT*, *GRHPR*, and *HOGA1*	AR	• CKD with progression to ESRD and risk of systemic oxalosis
Infantile hypercalcemia	• *CYP24A1* and *SLC34A1*	AR	• Hypercalcemia
Cystinuria	• *SLC3A1* and *SLC7A9*	AR or AD	• Cystine stones and nephrocalcinosis
Hereditary hyperuricosuria	• *HPRT1*	XLR	• Hyperuricemia, neurologic deficits (psychomotor delay, intellectual disability), and renal failure
Hereditary xanthinuria	• *XDH*, *MOCOS*, *MOCS1*, *MOCS2*, and *GPHN*	AR	• Myopathy, psychomotor deficit, growth delay, seizure, and hypotonia
Adenine phosphoribosyltransferase deficiency	• *APRT*	AR	• Crystalluria and progressive CKD

AD, autosomal dominant; AR, autosomal recessive; CKD, chronic kidney disease; ESRD, end-stage renal disease; LMW, low molecular weight; PTH, parathyroid hormone; XLR, X-linked recessive.

MONOGENIC ASSOCIATIONS WITH STONES - EVEN MORE LIKELY IN KIDS

- 14 GENES ACCOUNTED 15% OF ALLCOMERS IN STONE CLINIC
  - 11% OF ADULTS, 29% OF KIDS
- 15/51 PATIENTS WITH FIRST STONE PRIOR TO AGE 25 IN ANOTHER CLINIC WITH PATHOGENIC SINGLE GENE MUTATION (29%)
- 24/32 PATIENTS SUSPECTED TO HAVE A HEREDITARY CAUSE OF STONE DISEASE HAD A PATHOGENIC MUTATION (75%)

Halbritter J et al, JASN 2014
Daga A et al, Kidney Int 2018
Huang L et al Mol Genet Genom 2022

Disorder	OMIM#	Gene	Age onset	Clinical features	Type of stone
		Family 24 Subfamily A poly-peptide 1		*Muscle*: hypotonia *Neurologic*: lethargy *Lab abnormalities*: hypokalemia, increased serum prostaglandin E2, hyperprostaglandinuria, hypercalciuria, occasional hypomagnesemia, hypochloremia, increased urinary potassium and chloride, hyposthenuria	
Bartter Syndrome Type 3	607364	*CLCNKB* Chloride Channel Voltage-sensitive Kb	Variable	*Eyes*: multifocal yellow-white geographic, solid, choroidal lesions along the retinal vascular arcades, echogenic placoid calcified lesions at level of the sclera and choroid, normal retina and retinal pigment epithelium overlaying lesions *Vascular*: low blood pressure *Kidneys*: renal salt wasting, renal potassium wasting, impaired reabsorption of chloride, polyuria, nephrolithiasis *Muscle*: generalized weakness *Metabolic features*: dehydration, hypokalemic metabolic alkalosis *Endocrine*: hyperactive renin-angiotensin system, elevated plasma renin, elevated plasma aldosterone *Lab findings*: hypokalemia, increased serum bicarbonate, increased urinary potassium and chloride, hypocalciuria or normocalciuria	Calcium
Hypocalcemia, autosomal dominant with Bartter Syndrome & ADH	601198	*CASR* Calcium-sensing Receptor	~ 4 years	*Growth*: short stature (rare) *Larynx*: laryngospasm (rare) *Kidneys*: hypercalciuria, nephrocalcinosis, nephrolithiasis, decreased renal function *Skeletal*: osteoarthritis, increased bone mineral density in lumbar spine *Muscle*: muscle cramp, carpopedal spasm, tetany	Calcium
Bartter Syndrome Type 2	241200	*KCNJ1* Potassium Inwardly-rectifying channel subfamily J Member 1	Antenatal	*Growth*: short stature, low birth weight, failure to thrive *Head*: large head, prominent forehead, triangular face, large pinnae, large eyes *Vascular*: low-to-normal blood pressure *Gastrointestinal*: constipation, vomiting, diarrhea *Kidneys*: renal salt wasting, renal potassium wasting, renal juxtaglomerular cell	Calcium

Schott C et al, Frontiers Urol 2022

FAMILY HISTORY AND STONES

IDIOPATHIC STONE DISEASE IS A POLYGENIC DISORDER WITH A STRONG INFLUENCE OF ENVIRONMENT ON EXPRESSION

DIET IS NOT PURELY ENVIRONMENTAL

TABLE 3

HERITABILITY ANALYSIS FOR THE MEAN MEAL CALORIC INTAKE AND MEAL MACRONUTRIENT AND FLUID INTAKES OF MZ AND DZ TWINS

	Intraclass Correlations		Falconer Heritability		LISREL Estimates			
	r_{MZ}	r_{DZ}	h^2	F Test	e^2	h_a^2	c^2	Fit
Freq.	0.403	0.241	0.324	1.59*	0.560	0.440		0.998†
KCal	0.598 >*	0.286	0.623	2.61*	0.352	0.648		0.970†
Grams	0.554	0.340	0.427	1.75*	0.425	0.575		0.926†
Carb.	0.605 >*	0.322	0.566	2.24*	0.359	0.642		0.981†
Fat	0.401	0.250	0.303	1.88*	0.534	0.466		0.970†
Prot.	0.534 >*	0.270	0.529	2.24*	0.419	0.582		0.975†
Alc.	0.494	0.265	0.457	1.37	0.517	0.483		0.992†
H_2O	0.540	0.371	0.339	1.62*	0.436	0.564		0.916†

See Table 1 for symbols.

de Castro JM. Physiol & Behavior 1993

Table III

Heritabilities of Dietary Measures

	h^2 unadjusted	h^2 unadjusted p-value	Proportion of variance of measure explained by covariates	h^2 adjusted for age, gender, height, weight	h^2 adjusted for age, gender, height, weight p-value
FFQ Dietary intake					
Total Protein, g	0.45	<0.001	10.8%	0.37	<0.001
Animal Protein, g	0.31	0.002	12.3%	0.24	0.013
Calcium, mg	0.56	<0.001	2.7%	0.50	<0.001
Oxalate, mg	0.25	0.011	2.7%	0.22	0.021
Fructose, g	0.26	0.007	2.6%	0.23	0.016
Sucrose, g	0.37	<0.001	2.2%	0.38	<0.001
Urine variables that reflect diet intake					
Sodium, mmol/day	0.00	0.50	16.5%	0.07	0.23
Potassium, mmol/day	0.00	0.50	16.2%	0.005	0.47
Volume, ml/day	0.30	0.002	1.9%	0.24	0.01

Adjusted models included age, sex, height, and weight.

Lieske J et al, J Nephrol 2016

EVALUATION OF PEDIATRIC STONE FORMER

- GENERAL HISTORY
- STONE HISTORY – STONE TYPE!
- FAMILY HISTORY
- DIETARY/LIFESTYLE HISTORY
- LABS/IMAGING
- 24 HR URINES!!

REQUIRED ELEMENTS FOR STONE FORMATION

- **SUPERSATURATION** OF URINE WITH STONE MATERIAL
  - CONCENTRATIONS OF STONE MINERALS EXCEED THE THERMODYNAMIC SOLUBILITY
  - LEVELS OF SUPERSATURATION IN THE URINE OF STONE FORMERS CORRELATE WITH STONE COMPOSITION
  - CALCULATED WITH COMPUTER PROGRAM (EQUIL2)

    TAKES INTO ACCOUNT: VOLUME, CALCIUM, OXALATE, PHOSPHORUS, MG, CITRATE, PH (CAP AND UA)
  - OFTEN EXPRESSED AS THE RATIO OF THE STONE SALT ACTIVITY PRODUCT TO ITS SOLUBILITY:
    - > 1 = SUPERSATURATION

SIGNIFICANCE OF URINARY SUPERSATURATION

- TREATMENT AIMED AT LOWERING SUPERSATURATION IS EFFECTIVE IN PREVENTING STONE RECURRENCE
- EMPHASIZES THE IMPORTANCE OF CONCENTRATION OF URINARY CONSTITUENTS, NOT JUST DAILY EXCRETION RATES
- SUPERSATURATIONS VARY OVER THE COURSE OF THE DAY, HIGHEST AT NIGHT

STONE TYPES IN PEDIATRIC NEPHROLITHIASIS

- CALCIUM OXALATE – 45-65%
- CALCIUM PHOSPHATE – 14-30%
- URIC ACID, STRUVITE, CYSTINE – 5-10%
- PRIMARY HYPEROXALURIA – 1-2%

Stapleton, FB. Endocrinol Metab Clin North Am 2002

Values larger, bolder and more towards red indicate increasing risk for kidney stone formation. See reverse for further details.

Stone Risk Factors / Cystine Screening: Negative (07/31/2023)

DATE	SAMPLE ID	Vol 24	SS CaOx	Ca 24	Ox 24	Cit 24	SS CaP	pH	SS UA	UA 24
03/27/24	S27574467	2.56	4.38	226	34	603	0.60	6.091	0.48	0.714
07/29/23	S27477430	1.28	7.20	142	36	594	0.66	5.911	1.12	0.612
REFERENCE RANGE		0.5 - 4L	6 - 10	male <250 female <200	20 - 40	male >450 female >550	0.5 - 2	5.8 - 6.2	0 - 1	male <0.800 female <0.750

Dietary Factors

DATE	SAMPLE ID	Na 24	K 24	Mg 24	P 24	Nh4 24	Cl 24	Sul 24	UUN 24	PCR
03/27/24	S27574467	217	40	109	0.782	50	214	45	10.92	
07/29/23	S27477430	142	55	119	0.611	35	153	44	8.98	1.2
REFERENCE RANGE		50 - 150	20 - 100	30 - 120	0.6 - 1.2	15 - 60	70 - 250	20 - 80	6 - 14	0.8 - 1.4

Normalized Values

DATE	SAMPLE ID	WEIGHT	Cr 24	Cr 24/Kg	Ca 24/Kg	Ca 24/Cr 24
03/27/24	S27574467		1111 *			203
07/29/23	S27477430	55.8	809	14.5	2.5	176
REFERENCE RANGE				male 11.9-24.4 female 8.7-20.3	<4	male 34-196 female 51-262

Pediatric Reference Ranges

Chemistry	AGE	MALE MEAN	MALE SD	FEMALE MEAN	FEMALE SD
SS CaOx	0 - 3.9	6.5	8.2	4.4	3.9
	4 - 6.9	6.2	4.7	4.1	3.2
	7 - 9.9	8.8	13.1	5.5	4.3
	10 - 12.9	7.0	6.2	5.5	4.6
	13 - 16	5.3	4.6	3.3	3.9
Ca 24/Kg	1 - 16	2.4	0.7	2.4	0.7
Ox24/1.73 m2	0 - 3.9	35.4	22.7	30.4	17.7
	4 - 6.9	35.3	25.9	29.0	18.3
	7 - 9.9	28.2	11.1	30.4	21.5
	10 - 12.9	28.9	14.7	27.6	38.3
	13 - 16	30.1	24.3	28.2	21.6
Cit 24/Cr 24	2 - 4.9	761	350	1012	350
	5 - 7.9	689	208	722	262
	8 - 10.9	663	260	735	281
	11 - 13.9	525	240	629	270
	14 - 16.9	360	168	537	225
pH	0 - 3.9	6.70	0.8	6.90	0.79
	4 - 6.9	6.45	0.67	6.50	0.4
	7 - 9.9	6.27	0.61	6.34	0.61
	10 - 12.9	6.38	0.54	6.38	0.88
	13 - 16	6.41	0.59	6.37	0.64
Ua24/1.73 m²	1 - 16	0.52	0.15	0.52	0.15
P 24/Kg	0 - 3.9	24.4	7.5	13.8	7.0
	4 - 6.9	17	10.5	14.8	5.9
	7 - 9.9	16.4	7.4	14.3	7.2
	10 - 12.9	15.5	7.0	11.1	5.2
	13 - 16	13.3	8.1	13.1	6.9
Mg 24/Kg	0 - 3.9	2.1	1.1	1.7	1.1
	4 - 6.9	2.1	1.3	2.0	1.3
	7 - 9.9	2.1	1.2	2.0	1.3
	10 - 12.9	1.7	0.9	1.2	0.9
	13 - 16	1.3	1.5	1.2	0.6

Table 1. Dietary factors and potential stone risk.

Dietary Factors	Modification	Potential Stone Risk
Fluid intake	Reduction	Increased urine saturation
Sodium intake	Increase	Increased urine calcium and reduced citrate excretion
Calcium intake	Reduction	Increased urinary oxalate excretion
Meat intake	Increase	Low urine pH, increased urine calcium and reduced citrate excretion
Fruits intake	Reduction	Low urine pH and reduced citrate excretion
Diet content in oxalate foods	Increase	Increased urinary oxalate excretion

Ferraro PM, Nutrients 2020

CHILDREN ARE NOT LITTLE ADULTS

Table 1. Prevalence of risk factors among children with urinary stone disease

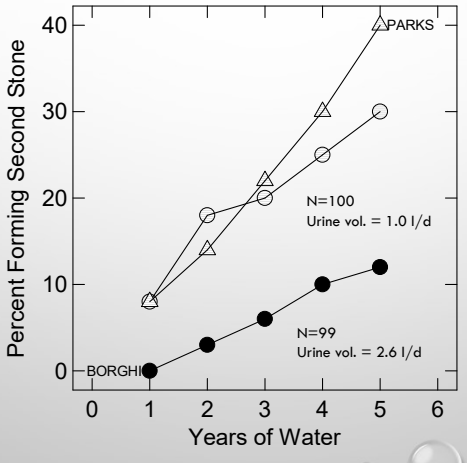
Risk factor	Prevalence among paediatric stone formers (%)[a]
Low urine volume/high urine osmolality	53–63
Hypercalciuria	13–47
Hypocitraturia	9–29
Hyperoxaluria	3–20
Hyperuricosuria	2–6
Hypomagnesuria	7–9

[a]Reproduced from [5,10–15].

Sas D. Curr Opin Ped 2020

FLUIDS

Randomized trial of water in single calcium stone formers, with an added set of prospective observations



Borghi, et. al. J. Urol 155:839, 1996

PEDS SPECIFIC RECOMMENDATIONS

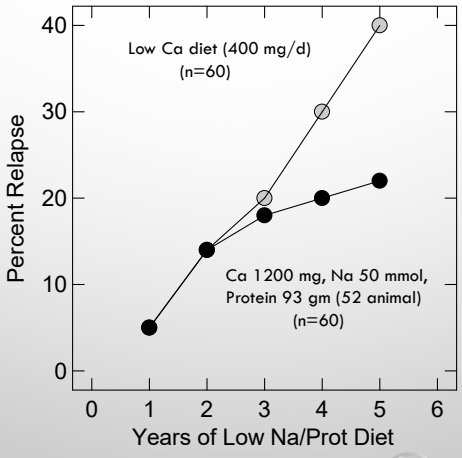
Table 2. Recommended water intake for children with urinary stone disease

Age (years)	Water intake per day	
	Litres	Ounces
Infant	0.75	25
Preschool	1	34
School-age	1.5	51
Adolescent	2	66
Adult	2.5–4	85–135

Sas D. Curr Opin Ped 2020

SODIUM

Low Ca diet vs. Normal Ca, low Na, low protein diet in men with IH and recurrent CaOx stones



Borghi et al; NEJM 346:77-84, 2002.

Table 3. Recommended sodium intake for children with urinary stone disease

Age (years)	Sodium intake (mg per day)
1–3	1000
4–8	1200
9–14	1500
14+	2000

Sas D. Curr Opin Ped 2020

How much sodium are children and youth in the U.S. eating?

On average, children ages 2 to 19 eat more than 3,100 milligrams (mg) sodium per day — about double the amount the American Heart Association recommends. The older children get, the more calories and sodium they tend to eat.

Research has shown that males 12 to 19 eat the most sodium — an average 4,220 mg/day, while females in the same age group eat about 2,950 mg/day.

Where do kids get their sodium?

Children 6 to 18 years old get about:

- 14% from breakfast
- 31% from lunch
- 39% from dinner
- 16% from snacks

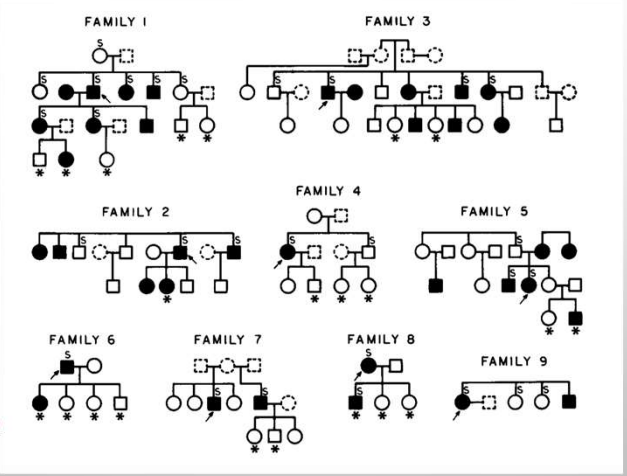
HYPERCALCIURIA

IDIOPATHIC HYPERCALCIURIA

- HYPERCALCIURIA WITH NORMOCALCEMIA IN THE ABSENCE OF OTHER DISORDERS KNOWN TO CAUSE HYPERCALCIURIA
- FOUND IN 50% OF CALCIUM STONE FORMERS
- FAMILIAL TRAIT
- DIET/LIFESTYLE INFLUENCES CALCIUM EXCRETION AND STONE RISK
- SYSTEMIC DISORDER INVOLVING BONE, INTESTINE AND KIDNEY

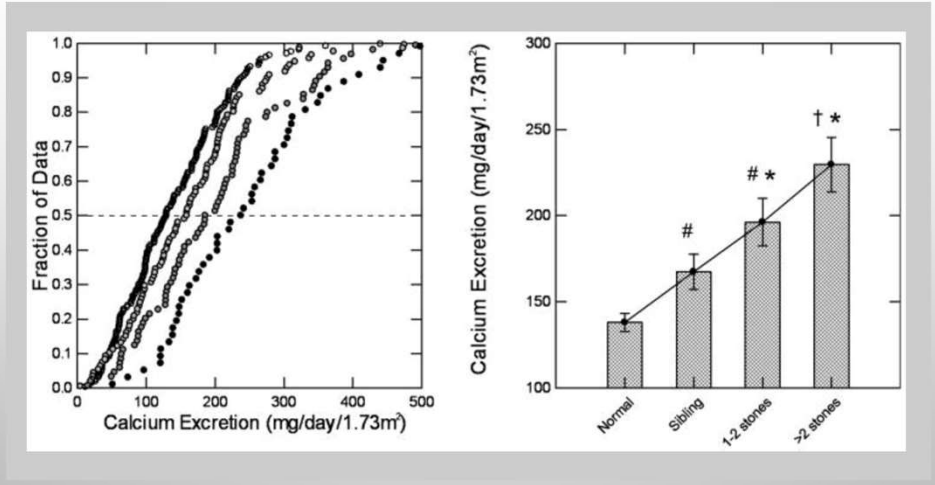
HYPERCALCIURIA

- MOST WELL ESTABLISHED RISK FACTOR FOR CALCIUM STONE DISEASE
- 43% OF 1ST DEGREE RELATIVES OF HYPERCALCIURIC PATIENTS ALSO WITH HYPERCALCIURIA



Coe FL et al, NEJM 1979 40

SIBLINGS OF CHILDREN WITH CALCIUM STONES HAVE HIGHER URINE CALCIUMS



THE UNIVERSITY OF CHICAGO MEDICINE

Bergsland K et al, KI 2012 41

RENAL CALCIUM EXCRETION

- INCREASED BY INCREASED SODIUM LOADS
- INCREASED BY SUGAR/FRUCTOSE
- INCREASED BY DIETARY PROTEIN/ACID LOAD

RECOMMENDED PROTEIN INTAKE

Table 1. Current recommendations for protein requirements, estimated by age and sex, for children.

	EFSA [1]			DRI [2]			
	AR (g/kg bw/d)	PRI (g/kg bw/d)	PRI (g/d)	EAR (g/kg bw/d)	RDA (g/kg bw/d)	RDA (g/d)	AMDR (%E) [3]
4–8 years	0.72	0.89	19.30	0.76	0.95	19	10–30%
9–13 years	0.72	0.90	34.50	0.76	0.95	34	10–30%
14–17 years, boys	0.71	0.88	53.25	0.73	0.85	52	10–30%
14–17 years, girls	0.69	0.85	46.50	0.71	0.85	46	10–30%

[1] From Ref. [26]. [2] From Ref. [15]. [3] From Ref. [30]. AMDR, Acceptable Macronutrient Distribution Range; AR, Average Requirement; DRI, Dietary Reference Intakes; EAR, Estimated Average Requirements; EFSA, European Food Safety Authority; PRI, Population Reference Intake; RDA, Recommended Dietary Allowance.

Garcia Iborra et al, Nutrients 2023

GOAL IS THE RECOMMENDED TARGET BUT…

- MOST CHILDREN AND ADOLESCENTS IN THE WESTERN WORLD ARE AT DOUBLE TO TRIPLE THE RECOMMENDED INTAKES OF PROTEIN

Berryman CE et al Am. J. Clin. Nutr. 2018
Lopez-Sobaler AM et al, Eur. J. Nutr. 2019

LIMIT CALCIUM?

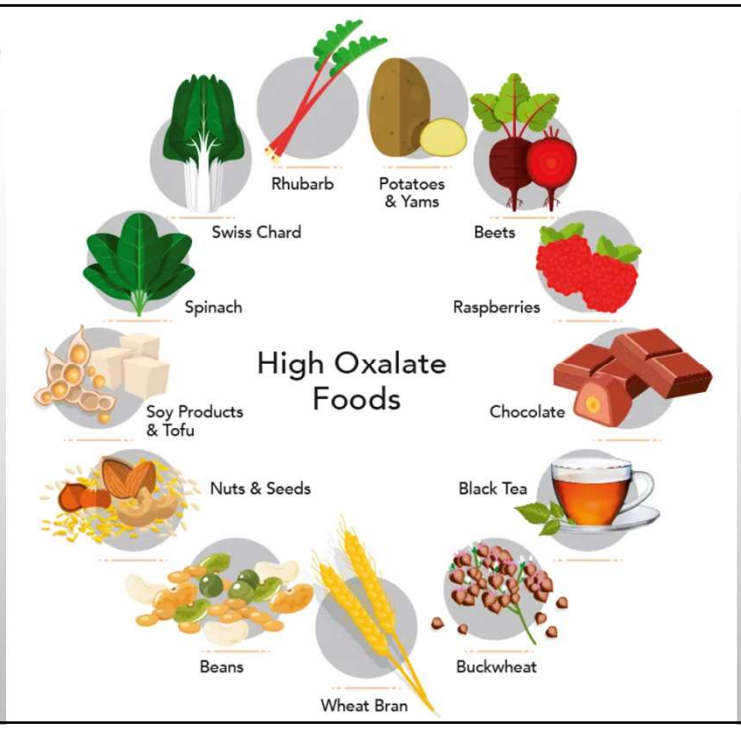
- NO!! NORMAL DIETARY CALCIUM INTAKE (700-1200 MG PER DAY)
- AVOID SUPPLEMENTS – AND IF MUST, TAKE WITH FOOD

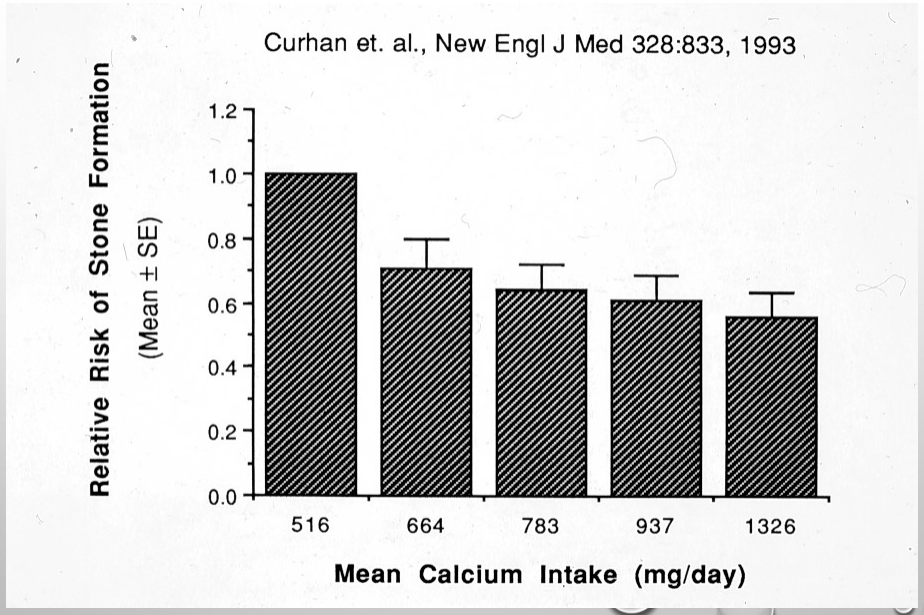
Carvalho-Salemi J, et al. Nutrients 2016

HYPEROXALURIA

APPROACH

- RULE OUT GENETIC DISORDERS FIRST
- ASSURE APPROPRIATE DIETARY CALCIUM INTAKE
- DETAILED DIETARY HISTORY (BAGS OF SAM'S CLUB ALMONDS?)
- DO NOT LIMIT HEALTHY FOODS IN DIET UNNECESSARILY





HYPOCITRATURIA

ETIOLOGIES OF LOW CITRATE

- HYPOKALEMIA
- METABOLIC ACIDOSIS/EXTREMES OF PROTEIN INTAKE
- CHRONIC KIDNEY DISEASE
- LOSS OF ALKALI VIA DIARRHEA/MALABSORPTION

DIETARY INTERVENTIONS

FRUITS AND VEGETABLES!!

MODERATION IN ANIMAL PROTEIN INTAKE

SUMMARY

- SIGNIFICANT INTERPLAY BETWEEN GENETICS, DIET, AND ENVIRONMENT
- MONOGENIC DISORDERS LIKELY UNDERLIE ABOUT 1/3 OF PEDIATRIC STONE DISEASE
- MECHANISM OF STONE FORMATION IS SUPERSATURATION – MONOGENIC OR POLYGENIC
- INDIVIDUALIZE DIETARY APPROACHES BASED ON ABNORMALITIES NOTED ON EVALUATION
- CAN'T GO WRONG WITH LOTS OF FLUIDS, FRUITS/VEGETABLES, AND MODERATION IN ALL ELSE

THANK YOU