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Research Article

Effect of Drinking Water Hardness on Kidney Stones Formation in Ranya District

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ABSTRACT

This study was conducted in Rania District, Raparin University, during September 2018–March 2019, to test the relation between water hardness and kidney stone formation. The investigation depended on questionnaire form which was distributed on 100 person in Raparin (Rania, Hajiawa, and Chwarqurna) and patients whom vested the Rania clinical during December 1, 2018–January 22, 2019 which were 238 patients and only 20 of them had kidney stones developing which represent 8.4% of the total kidney diseases. The results indicated to significant effect of gender at level of significant 5% on kidney stones formation, 10% of male, and 18% of female having kidney stones. The results of Chi-square test indicated to highly significant effect of age on kidney stone formation at level of significant (0.001). The kidney stone formation increased from 19.23% to 75% with an increase in age class from (14–34) to (54 or more) year. The negative correlation coefficient value of ($r = -0.63$*) was recorded between water hardness and stone risk index due to the high magnesium content of drinking water in the studied area.

Keywords: Ca-hardness, component, Mg-hardness, stone risk index, total water hardness

INTRODUCTION

The urolithiasis regards as a very complex disease, many factors affecting on urinary calculus or formation of kidney stones.[1]

Hard water means the water which contains more minerals in comparing with ordinary water. The most important ions are calcium and magnesium. Hardness is expressed in terms of calcium carbonate ($CaCO_3$) mg/l. The degree of hardness increases with increasing the concentration of calcium and magnesium in water if the concentration of them <75 m/l is considered as a soft water, 76–150 mg/l moderately hard, and more than 150 mg/l regards as a hard water.[2]

Numerous studies were conducted in the Kurdistan region about water quality and its suitability for drinking purpose, most of them included total hardness, magnesium hardness, and calcium hardness water which directly related to kidney stones developing or forming or regards as one of the factors related to kidney stone formation in the world depending on type of water hardness and magnesium and bicarbonate concentration in drinking water.[1,3]

Several factors increase the risk for kidney stones forming or developing which were summarized as inadequate water or fluid intake and dehydration, reduce in urinary volume, and increase in concentrations or levels of certain chemicals in urine such as calcium, oxalate, and uric acid to high level or decrease of magnesium to low level or too low and some medical conditions such as reflux and medullary sponge kidney urinary tract infections in additional to tubular acidosis. Anything that reduces or blocks the urine flow like urinary obstruction and genetic abnormalities also increase the risk of kidney stones developing.[4]

Drinking water hardness in the Kurdistan region studied by numerous researchers as follow:

The water harness in Sulaimani governorate the results indicated that the total hardness was ranged (from 110 to 280) mg $CaCO_3$/l, it means most of the studied water hard and may have negative effect of kidney stone developing.[5]

The water harness study of (Chaq–Chaq) Kliassan stream in Sulaimani city showed that the total hardness was ranged from 110 to 355 mg/l; it means most of studied water hard

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to very hard and could have negative effect of kidney stone formation.[6]

The water hardness of karees, springs, and streams in Erbil governorate was studied by Esmail,[7] the results explained that the total hardness was ranged from 151 to more than 1000 mg/l with a mean of 321 mg/l. It means most of the studied water was hard to very hard.

The water hardness of Kapran near Erbil city was studied, the results indicated that the total hardness was ranged between 135.48 and 306.93 mg means must studied moderate hard to very hard.[8]

The water hardness of springs at Halgwrd mountain was ranged between 93 and 122 mg/l $CaCO_3$, it means that the water of this location is must soft water and suitable for drinking purpose depending on.[9,10]

The water hardness in Erbil was ranged (138–446) mg $CaCO_3$/l, it means most of the studied water was hard to very hard.[11]

The value of total hardness of the water in Bator and Southwest and south Erbil was ranged between 173 and 900 mg $CaCO_3$/l, this indicated that most studied water had hard to very hard class or not suitable for drinking purpose[9] or may have negative effect kidney stone developing.[8,12]

The mean of total hardness, Ca-hardness, and Mg-hardness was (248.82–339.30), (207.49–291.21), and (41.34–97.57) mg/l, respectively, for drinking water in Halabja as mentioned by Schwart *et al*.[13]

The studied water hardness in Dohuk governorate had the values ranged between 281 and 972 mg/l as $CaCO_3$; it means most of the studied water had hard to very hard class.[14]

The water hardness of the studied water in Sulaimani governorate recorded the total hardness of (200–580) mg/l as $CaCO_3$ means; it refers to that the studied water has hard to very hard class and may have negative effect on kidney stone forming.[15]

The inverse relationship was recorded between drinking water hardness and kidney stones developing (urolithiasis) for 2302 patients in various geographical regions of the united state.[16]

The workers found the positive correlation between drinking water hardness and kidney stones forming and developing (urolithiasis) in 1000 general hospitals in the United States of America. On the other hand, the weak correlation was recorded between kidney stone-forming and drinking water hardness as mentioned by Churchill *et al*.[17] and Shuster *et al*.[18]

The positive correlation was recorded between total water hardness and kidney stones forming in the United Kingdom, due to the water hardness values in South and East of England.[19]

The relation between drinking water quality (hardness) and the stone risk index (SRI) (kidney stone forming) for 24 Provincial Capitals of Iran, was studied by Basiri *et al*.[1] The results indicated that the water hardness was ranged between 57 and 874 PPM; the SRI was ranged between 0.00 and 0.0198. The non-significant correlation was recorded between total water hardness of tap water and kidney stone formation, while the negative significant correlation was recorded between Mg-hardness and kidney stone formation with the correlation coefficient value of $r = -0.51^*$.

In the study conducted in Iran from 20 capital cites depending on large number of samples (21200) the negative significant correlation means increase in water hardness cased decrease in risk of kidney stone forming since 30% of total hardness is magnesium hardness which causes decrease in stone formation.

Since the drinking water of the Kurdistan region is hard, especially the water of springs, wells, and rivers in Raparin District is hard to very hard which ranged from 150.46 to 1414.80 with the mean value of 337.71 mg/l as $CaCO_3$. It means the water hardness of water in the Kurdistan region is above the recommended standard value of WHO.[9]

For the above reasons, the aims of this investigation are to study the effect of:

1. Drinking water hardness on kidney stones developing or formation.
2. Amount of water intake per day, gender, age, and family history on developing kidney stones.

MATERIALS AND METHODS

For scientific research about the effect of drinking water hardness on kidney stones forming, the data were collected from December 1, 2018 to January 20, 2019 in one clinic of Rania city specialized in kidney diseases. The number of patients visited the mentioned clinic was 238 patients and only 20 of them had kidney stones developing or forming.

The other source of data collecting was the distribution of questionnaire form on 100 persons (50 male and 50 female) inside and outside of Raparin University, which included (Hajyawa, Chwarqwrna, and Ranya), the questionnaire form was shown from Table 1 which prepared as mentioned from 20.

The survey was conduct on water hardness in the Kurdistan region, while 52 water samples in Raparin District was depended in calculating risk index of stone formation. The water sample was analyzed from Raparin during 2018 by Dawson,[20] the total water hardness, magnesium hardness, and calcium hardness we determined according to following models and stone risk formation for 52 samples of water were calculate using following equation as mentioned by Basiri *et al*.[1]

Stone risk index = SRI = [(Ca mg/l)/(Mg mg/l)]/(bicarbonate (mg/l).

Table 1: The questionnaire form

Age	Gender		
	Male	Female	
Source of drinking water	Spring	Well	
Amount of red meat eat	High	Medium	Low
Amount of water intake L/day	3–4	2–3	1–2 L/day
Family history	Yes	No	

Total hardness = [Ca mg/l*2.50+Mg mg/l*4.20].
Mg-hardness = (Mg mg/l*4.20).
Ca-hardness = Total hardness−Mg-hardness.

The statistical analysis was conduct using Chi-square test depend on the SPSS program version (22) and regression correlation curve was drown using Excel program.

RESULTS

As shown from Table 2, the gender affected significantly on kidney stones forming at level of significance (0.05), the statistical analysis indicated that the calculated Chi-square value (3.81) is more than tabulated value (3.50). The results indicated that 10% of male and 18% of female having kidney stones forming depending on total sample size (100). On the other hand, if the percentage was calculated separately for male and female, the percentage of samples having kidney stones forming was 20 and 30% for male and female, respectively.

Table 3 indicates to the highly significant effect of age on kidney stone formation at the level of significant (0.001) with the calculated Chi-square value of 15.50. The kidney stone formation increased from 19.23% to 75% with increase in age.

Table 4 indicates to the effect of source of drinking water on kidney stone was not significant in spite of the percentage of kidney stone in case of a source of drinking spring water was 20%, while the percentage was 29.415 in case of drinking well water.

Table 5 explains that the amount of consumed meat per person had not affected significantly on kidney stones. Chi-square test refers to non-significant effect since the calculated Chi-square value (1.29) is less than tabulated value (3.40).

Table 6 explains that the amount of drinking water (L/day/person) had not affected significantly on kidney stone formation. Chi-square test refers to non-significant effect since the calculated Chi-square value (1.290) is less than table value.

Table 2: The effect of gender on kidney stone

Gender	Kidney stone		Percentage of patients having kidney	
	Have	Have not	From subsample	From total (n=100)
Male	10	40	20	10
Female	18	32	30	18
Total	28	72		28
Calculated Chi-square=3.81	Tab. Chi-square=3.50		$P \geq 0.05$	

Table 3: Explains the effect of age on kidney stone

Age (year)	Have kidney stone	Have not kidney stone	Percentage of patients having kidney stone
14–34	16	67	19.23
34–54	9	4	69.23
54 or more	3	1	75.00
Calculated Chi-square value (X^2)=15.50***		Tab. Chi-square=3.20	$P \geq 0.001$

Table 4: Indicates to the effect of source of drinking water on kidney stone

Source of water	Have kidney stone	Have not kidney stone	Percentage of patients having kidney stone
Spring	3	12	20.00
Well	25	60	29.41
Calculated Chi-square=3.00		Tab. Chi-square=3.50	$P \geq 0.15$

Table 5: Indicates to the effect of eating meat on kidney stone

Meat consumption	Have kidney	Have not kidney stone	% of patients having kidney stone
High	7	25	21.88
Medium	12	23	34.29
Low	9	24	27.27
Calculated Chi-square=1.29		Tab. Chi-square=3.40	$P \geq 0.53$

Table 6: Indicates to the effect amount of drunken water (L/day) on kidney stone-forming

Amount of drunk water L/day	Have kidney stone	Have not kidney stone	Percentage of patients having kidney stone
Low (1–2)	16	33	32.65
Medium (2–3)	6	15	28.57
High (3–4)	6	24	20.00
Calculated Chi-square=1.47		Tab. value=3.20	$P \geq 0.47$

Table 7: Effect of family history on kidney stone formation

Family history	Have kidney stone	Have not kidney stone	Percentage of patients having kidney stone
Yes	11	23	32.35
No	17	49	25.76
Calculated Chi-square=0.48		Tab. value=3.50	$P \geq 0.49$

Table 8: Explains some important chemical properties of water samples in Raparin District

Location	Concentration (mg/L)			SRI	Hardness (mg/$CaCO_3$/L)		
	Mg^{2+}	Ca^{2+}	HCO_3		Mg^{2+}	Ca^{2+}	HCO_3
1-Spring	17.92	61.80	301.65	0.42	73.63	153.88	227.52
2-River	10.27	44.18	286.88	0.55	42.22	110.01	152.23
3-Spring	56.93	267.50	3057.93	0.06	233.97	666.08	900.05
4-Well	30.49	128.20	1653.10	0.09	125.32	319.22	444.54
5-Well	23.64	102.80	547.48	0.29	97.16	255.97	353.13
6-Well	23.02	91.86	474.46	0.31	94.60	228.73	323.33
7-Spring	19.93	59.78	318.54	0.34	81.92	148.85	230.77
8-Well	17.53	44.62	256.75	0.36	72.06	111.10	183.16
9-River	31.42	65.08	1164.49	0.07	129.12	162.05	291.17
10-Spring	11.94	50.48	238.39	0.65	49.07	125.70	174.77
11-Spring	17.11	88.30	454.08	0.42	70.33	219.87	290.20
12-Spring	20.81	88.52	402.05	0.39	85.52	220.41	305.94
13-Well	12.55	209.80	990.03	0.62	51.59	522.40	573.99
14-Well	15.72	146.00	735.66	0.46	64.61	363.54	428.15
15-Well	19.68	69.40	418.22	0.31	80.88	172.81	253.69
16-Well	11.81	63.16	273.65	0.72	48.53	157.27	205.80
17-Well	21.60	96.34	506.91	0.32	88.78	239.89	328.66
18-Well	24.24	83.22	408.64	0.31	99.63	207.22	306.84
19-Well	30.36	100.80	513.80	0.24	124.78	250.99	375.77
20-Spring	28.30	89.88	433.77	0.27	116.30	223.80	340.10
21-Spring	26.56	78.10	387.17	0.28	109.15	194.47	303.61
22-Spring	94.99	411.40	1808.65	0.09	390.42	1024.39	1414.80
23-Spring	26.74	65.44	349.90	0.26	109.88	162.95	272.83
24-Spring	28.30	78.90	409.86	0.25	116.30	196.46	312.76
25-Spring	26.44	69.08	356.67	0.27	108.65	172.01	280.66
26-Spring	26.71	70.06	371.55	0.26	109.79	174.45	284.24
27-Spring	12.22	40.26	193.68	0.62	50.21	100.25	150.46
28-Spring	63.29	234.80	1091.90	0.12	260.11	584.65	844.77
29-Spring	38.04	108.90	575.29	0.18	156.34	271.16	427.51
30-Well	12.88	55.38	257.73	0.61	52.92	137.90	190.82
31-Well	15.78	60.48	296.95	0.47	64.86	150.60	215.45
32-Well	14.42	55.46	271.51	0.52	59.28	138.10	197.38
33-Spring	29.57	95.16	459.33	0.26	121.52	236.95	358.47
34-Spring	31.03	113.70	527.47	0.25	127.54	283.11	410.65
35-River	41.88	99.14	551.32	0.16	172.13	246.86	418.99
36-Spring	20.29	64.86	315.92	0.37	83.40	161.50	244.90
37-Spring	13.08	43.92	220.33	0.56	53.76	109.36	163.12

(*contd...*)

Table 8: *(Continued)*

Location	Concentration (mg/L)			SRI	Hardness (mg/$CaCO_3$/L)		
	Mg^{2+}	Ca^{2+}	HCO_3		Mg^{2+}	Ca^{2+}	HCO_3
38-Spring	18.40	69.06	328.12	0.42	75.61	171.96	247.57
39-Well	10.76	61.48	270.35	0.77	44.24	153.09	197.33
40-Spring	17.15	53.76	265.11	0.43	70.48	133.86	204.34
41-Well	18.06	77.78	355.94	0.44	74.23	193.67	267.90
42-Well	19.45	60.42	304.45	0.37	79.95	150.45	230.39
43-Well	23.62	80.14	388.39	0.32	97.06	199.55	296.61
44-Well	21.78	76.40	406.50	0.32	89.52	190.24	279.75
45-Well	27.19	91.88	451.03	0.27	111.76	228.78	340.54
46-Well	34.02	69.10	412.85	0.18	139.82	172.06	311.88
47-Spring	17.22	60.98	297.50	0.44	70.77	151.84	222.61
48-Well	24.38	84.04	416.33	0.30	100.22	209.26	309.48
49-Well	41.02	84.52	553.15	0.14	168.58	210.45	379.03
50-Well	25.16	101.50	476.59	0.31	103.42	252.74	356.16
51-Well	24.96	92.58	442.01	0.31	102.59	230.52	333.11
52-Spring	26.51	118.10	613.05	0.27	108.95	294.07	403.02
Min	10.27	40.26	193.68	0.06	42.22	100.25	150.46
Max	94.99	411.40	3057.93	0.77	390.42	1024.39	1414.80
Average	25.33	93.82	535.83	0.35	104.11	233.61	337.71

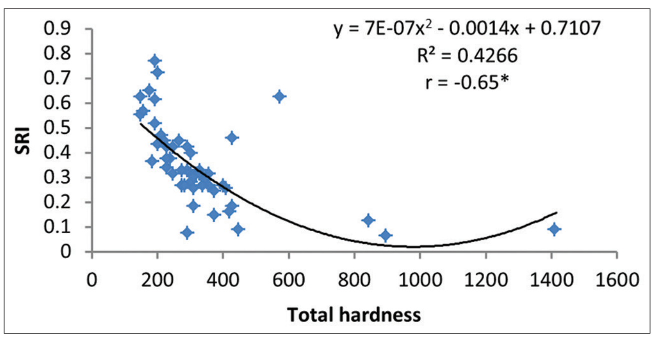

Figure 1: Relation between total hardness of drinking water and stone risk index of kidney

Table 7 explains that the family history of the studied samples person had not affected significantly on kidney stone formation. Chi-square test refers to non-significant effect since the calculated Chi-square value (0.484) is less than tabulated value.

Figure 1 shows the correlation between SRI and total hardness of 52 water resources (rivers wells and springs) in Raparin District. The coefficient of determination (R^2) and correlation coefficient (r) between them was 0.426 and −0.65*, respectively. The SRI, coefficient of determination (R^2), and correlation coefficient (r) were determined from the data recorded in Table 8.

DISCUSSION

Table 2 shows that the gender affected significantly on kidney stone formation the highest value (18%) was recorded from female, while (10%) was recorded from male this may be due to human activity of male more than female or may be due to biological difference male and female and lifestyle.

Table 3 refers to highly significant effect of age on kidney stone (0.001). The kidney stone information increased from 19.25% to 75% for age class of (14–34) year to age class of more than (54) year, respectively, since every 10 years the kidney stone formation is possible as mention by Basiri *et al.*[1] and Kumar *et al.*[4] The statistical analysis using Chi-square test also indicated to significant effect of age on kidney stone formation since the calculated Chi-square value (15.50) was more than tabulated value which was equal to 3.50. On the other hand, the reverse results can be obtained depending on total sample size of this study because the sample size increased with decrease in age.

Table 4 explains that non-significant effect of source of drinking water on kidney stone formation or there was no significant difference between water hardness of spring water and well water since both of them are hard water to very hard water.[9]

The Mg-hardness represents 31% of total hardness as shown from Table 8, similar results were obtained by Basiri *et al.*[1] in the main cities of Iran which caused decrease in risk of stone formation. The significant negative correlation coefficient was recorded between the risk of stone formation and total hardness of 52 water samples in Raparin District with the value of $r = -0.65^{**}$ as shown from Figure 1 which decrease in the effect of total hardness of drinking water in kidney stone formation. These results agree with those recorded by Basiri *et al.*[1]

Table 5 explains that consumed meat not affected significantly on kidney stone formation in spite of the difference in the percentage of kidney stone formation which ranged between (21.88% and 34.29%).

Table 6 indicates to decrease in kidney stone formation from 32.65% to 20% with increase amount drunk water per day or water intake per day per person, this may be due to increase water may be prevent precipitation of crystals such as calcium, oxalate, and uric acid in the kidney then decrease stone formation.

As shown from Table 7, the family history caused an increase in percentage of kidney stone formation from 25.76% to 32.35% but not reached to the significant effect.

Its appear from the above discussion that there is more than one factor responsible for kidney stone formation for this reason, sometime the result for single factor is not significant, while the combination among the studied factors may cause the kidney stone formation.

CONCLUSION AND RECOMMENDATIONS

The kidney stone formation affected significantly by gender and amount of drunken water (L/day/person). The total water hardness was not affected significantly on kidney stone formation since magnesium hardness represents 31% of total hardness which caused decrease in the risk of kidney stone formation. The drinking water in Raparin District is hard to very hard, but they have not risk on kidney formation due to high magnesium and bicarbonate of the studied water resources.

We highly recommend that:
- It is necessary to increase sample size.
- It is better to have the same number of studied samples for each age classes.
- It is better to have the same number of male and female number in the suture studies.

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