Original Research Article

Skeletal flourosis and chronic renal failure

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Abstract

Flourosis has a world wide occurence posing a serious health problems. Approximately 25 to 30 million people are exposed to water polluted with flouride. Half to one million people are suffering from severe forms of flouride intoxication in our country. In Telengana,Flourosis was detected as early as in 1937, the problem being acute in Nalgonda District. It is observed that hidden renal disease is one of the main factors for development of skeletal flourosis early. Individuals suffering from latent renal disease develop skeletal flourosis early,even while consuming low levels of flouride. In this study, 52 cases of skeletal flourosis with chronic renal failure were described between 1983 to 1998. A detailed clinical evaluation and skeletal survey were carried out for flourosis. Renal function tests were carried out to assess renal function. Ultra sound examination of abdomen was carried out to assess the size of the kidneys. The results and pathophysiology were also discussed.

Key words

Skeletal flourosis, Chronic renal failure, Kidney size.

Introduction

Hidden renal disease is one of the main factors for development of skeletal flourosis. It has been estimated that 25 to 30 million people are exposed to water containig more than the permissible limits of flouride and that half to one million people are suffering from severe forms of flouride intoxication in our country [1].

In one of the studies [2] of 41 cases of skeletal flourosis,9 were found to have impaired kidney function and 32 had normal kidney functions.In normal individuals urinary flouride fluctuates widely between 0 and 1.2 ppm,with an average of about 0.4 ppm when the flouride content of drinking water is 0.3 ppm. Flouride is removed from circulation by glomerular filtration.Tubular reabsorption of flouride is less than that of

chloride and thus the kidney excretes flouride rapidly.

Individuals suffering from latent renal disease may develop skeletal flourosis even while consuming low levels of flouride of 1-2 ppm in drinking water. The types of kidney disorders detected in our study were unilateral or bilateral contracted kidneys, hydronephrosis and non functioning kidneys, in descending order of frequency [3].

Flouride metabolism

When equal amounts of flouride is fed to animals of different ages, the bones of the mature animals acquired less flouride than those of younger ones [4]. Even in individual bones, the metabolically active metaphyseal cortex and periosteal bone took up flouride more than mid-cortical compact bone [5]. Accumulation of flouride in bone forming tissues ,begins during foetal development, flouride clearly enters the foetal circulation and is incorporated in the developing bones and teeth [5-7].

Roughly 50 % of a flouride ingested by an adult will be excreted in the urine and most of the remainder will be taken up by calcified tissues. The major route for the elimination of flouride from the body is the kidney.

Absorption

The major route of flouride absorption is ingestion via the gastro-intestinal tract. Absorption of flouride taken on a fasting stomach as Naf tablets was essentially equal to 100%. It decreased to 70%, when the same tablets were taken together with a glass of milk,and 60% when the same tablets were taken together with a calcium rich breakfast [8]. By passive diffusion flouride is absorbed both from stomach and intestine.

Distribution

Flouride is distributed from the plasma to all tissues and organs. Flouride is concentrated to high levels within the kidney tubules, so that taken as a whole, this organ has a higher concentration than that of plasma [9].

Distribution to calcified tissues

Flouride is an avid calcified tissue seeker. Its clearence rate from plasma by bone is even higher than that of calcium. Approximately 99% of all the flouride in the human body is found in calcified tissues [10]. During the growth phase of skeleton, a relatively high portion of an ingested flouride dose will be deposited in the skeleton. Further, a larger fraction of a single dose given to a very young individual will be deposited in the skeleton compared with the same dose given to an adult [11]. During normal conditions approximately one half of the daily flouride intake by adult will be deposited in the skeleton and the rest excreted in the urine [12]. Flouride is not irreversibly bound to the bone. This has been demonstrated in individuals who moved from an area with a high flouride concentration in the drinking water to an area with a lower flouride level. By measuring the urinary flouride concentration in these individuals, it was shown that the levels remained unusually high for long periods [13, 14]. The plasma concentration and the urinary excretion mirror a physiological balance that is determined by earlier flouride exposure, the degree of accumulation of the ion in bone, the mobilization rate from bone and the efficiency of the kidneys in excreting flouride.

Excretion – renal handling of flouride

The major route for the removal of flouride from the body is by the kidneys. Because ionic flouride is not bound to plasma proteins [15, 16], its concentration in the glomerular filtrate is undoubtedly the same as it is in plasma water. After entering the renal tubules, a variable amount of the ion will be reabsorbed and returned to the systemic circulation. The remainder will be excreted in the urine.

On this basis, it is apparent that the first determinant of the amount of flouride excreted in the urine is the glomerular filtration rate. If this rate is reduced for any reason, such as chronic renal failure, it will be reflected in increased plasma and bone flouride levels. Several studies

have shown that if the glomerular filtration rate is severely reduced (to about 30% of normal or less) on a chronic basis the plasma flouride levels are markedly elevated [17, 18]. The degree of reabsorption of filtered flouride depends largely on the pH of tubular fluid. As the tubular fluid becomes more acidic, more of the ionic flouride is converted into HF (Hydroxy Flourate). This increases the chemical potential(concentration gradient) for HF and promotes its diffusion out of the tubules. Conversely, as the tubular fluid becomes more alkaline, more of the flouride exists in the ionic form. The ion is considered relatively impermanent so that it remains within the tubules to be excreted [19]. A wide variety of factors can influence pH of tubular fluid including the composition of the diet, the attribute of residence, certain drugs and a large number of respiratory or metabolic diseases. For example, a vegetarian diet promotes a more alkaline urine than does a diet mainly composed of meats [19]. Therefore compared with a meat diet, a vegetarian diet would cause a less positive flouride balance.

Material and methods

In this study, 52 cases of skeletal flourosis with chronic renal failure were described between 1983 to 1998. A detailed clinical evaluation and skeletal survey were carried out for flourosis. Renal function tests were carried out to assess renal function. Ultra sound examination of abdomen was carried out to assess the size of the kidneys.

Results

Patient characteristics

The study retrospective in nature comprised of 52 cases skeletal flourosis admitted between 1983 to 1998 in Medical Unit at Osmania General Hospital,Hyderabad. Most of the patients belong to Nalgonda,which is endemic region for flourosis, followed by Hyderabad, which is a neighbouring district (**Table – 1**).

Age distribution

Flourosis was more common in more productive age goups between 21-30 and 41-50 years (**Table - 2**).

Sex distribution

Males (36) outnumberd females (16) as per **Table - 3**.

Table – 1: Patient's native place.

Name of the district	No. of patients
Nalgonda	20
Hyderabad	16
Mahboobnagar	04
Warangal	04
Karimnagar	04
Rangareddy	04

Table – 2: Age distribution.

Age distribution (years)	No. of patients
21-30	12
31-40	08
41-50	24
51-60	04
61-70	04

Table – 3: Sex distribution.

Sex	No. of patients
Male	36
Female	16

24 hours urinary proteins

24 Patients had < 1 g, 28 Patients had > 1 g of 24 hour urinary protein as per **Table - 4**.

Blood urea levels

22 patients had < 40 mg%, 30 patients had > 40 mg% of blood urea level as per **Table – 5**.

Serum creatinine levels

11 patients had < 1.0 mg %, 41 patients had > 1. 0 mg %, 29 patients had > 4.0 mg % and 16 had end stage renal disease (ESRD) as per **Table – 6**.

Serum calcium levels

32 patients had normal calcium levels, and 20 patients had > 9.0 mg% (**Table - 7**).

Serum posphrus levels

44 patients had phosphorus < 5.0 mg%, and 8 patients had > 5 mg % (**Table - 8**).

Table – 4: 24 hours urinary proteins.

Range of 24 hours urinary proteins	No. of patients
More than 1 g	24
Less than 1 g	28

Table – 5: Blood urea levels.

Blood urea levels (mg%)	No. of patients
10 – 20	10
21 – 40	12
41 – 60	06
61 – 80	06
81 – 100	06
101 – 120	06
121 – 140	02
141 – 160	02
161 – 180	02

Table – 6: Serum creatinine levels.

Serum creatinine levels (mg%)	No. of patients
Less than 1	11
1.0 – 3.9	12
4.0 – 6.9	13
7.0 – 9.9	08
10.0 – 12.9	08

Table – 7: Serum calcium levels.

Serum calcium levels (mg%)	No. of patients
7.0 – 7.9	12
8.0 – 8.9	20
9.0 – 9.9	12
10.0 – 10.9	08

Table – 8: Serum posphrus levels.

Serum posphrus levels (mg%)	No. of patients
1.0 – 5.0	44
5.1 – 10.0	04
10.1 – 15.0	04

Kidney size

40 patients had bilateral small kidneys, 8 patients had bilateral rormal kidneys,and 4 had bilateral enlarged kidneys (**Table – 9**).

Serum creatinine vs kidney size

While evaluating kidney size and correlating with serum creatinine levels, interestingly, it was found that out of 40 patients with small kidneys, 11 had normal serum creatinine levels (**Table - 10**).

Table – 9: Kidney size.

Kidney size	No. of patients
Bilateral small kidneys	40
Bilateral normal kidneys	08
Bilateral enlarged kidneys	04

Discussion

In the present study, renal functions were evaluated in 52 cases of skeletal flourosis. While evaluating kidney size and correlating with serum creatinine levels, interestingly, it was found that out of 40 patients with small kidneys, 11 had normal serum creatinine levels. It makes us think that the skeletal flourosis may be the forerunner in causing chronic renal failure. Conversely in presence of chronic renal failure, skeletal flourosis may manifest early,as evidenced in this study, 12 patients (in the age groupof 21-30 years) had skeletal flourosis with bilateral small kidneys.

In one of the other studies [2] of 41 cases of skeletal flourosis, 9 were found to have impaired kidney function and 32 had normal kidney functions. It is observed that hidden renal disease is one of the main factors for development of skeletal flourosis. Individuals suffering from latent renal disease may develop skeletal flourosis even while consuming low levels of flouride of 1-2 ppm in drinking water. Hence, it is pertinent that ultrasound of abdomen for kidney size should be done in all cases of skeletal flourosis. It is also pertinent to point out that majority of these patients had normal blood urea, serum creatinine levels. Abnormalities of renal

parenchyma were detected only in ultrasound scan [3].

The factors influencing acidic pH [19] are very much prevailing in these regions of Telangana especially Nalgonda district. These people work in hot summers losing water from the body by severe sweating with scarce availability of potable (flouride free) drinking water. The tubular fluid in acidic medium promotes formation hydroflouride and the concentration gradient is increased and that promotes diffusion of flouride out of the tubules into all the tissues of the body. Where as tubular fluid which is alkaline maintains flouride in ionic form, and there is no concentration gradient and the flouride in ionic form is relatively impermeable and remains within the tubule to be excreted. Therefore acidic pH promotes flourosis.

Table – 10: Serum creatinine vs kidney size.

Total no. patients with skeletal flourosis (52)			
Size of the kidneys	**No. of patients**	**Serum creatinine (normal)**	**Serum creatinine (raised)**
Bilateral small kidneys	40	11	29
Bilateral normal kidneys	8	8	0
Bilateral enlarged kidneys	4	0	4

For example, a vegetarian diet promotes a more alkaline urine than does a diet mainly composed of meats [19]. Therefore compared with a meat diet, a vegetarian diet would cause a less positive flouride balance. The food which they consume in Telangana, is mostly vegetarian (grown on flouride soil, with flourine containig water), is also a contributory factor. Non vegetarian food is less contributing to flourosis, but patient cant afford because of prevailing poverty. Among the food groups the grains and cereal products,which constitute staple food in Telangana, have highest flouride (0.241 mg) concentration.

Flouride is removed from circulation by glomerular filtration. Individuals with latent renal disease may develop skeletal flourosis even while cosuming low levels of flouride. It was found,in this study, that out of 40 patients with small kidneys, 11 had normal serum creatinine levels. Hence, hidden renal disease is one of the main factors for development of skeletal flourosis. Hence,it is pertinent that ultrasound of abdomen for kidney size should be done in all cases of skeletal flourosis. It is also necessary to point out that majority of these patients had normal blood urea, serum creatinine levels. Abnormalities of renal parenchyma were detected only on ultrasound scan for kidney size [2, 3].

Conclusion

Ultrasound of abdomen for kidney size should be done in all cases of skeletal flourosis. Majority of skeletal fluorosis had normal blood urea, serum creatinine levels.

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