

INFRARED SPECTROSCOPY IN KIDNEY AND BILIARY STONE DISEASE

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Summary: Nephrolithiasis is a complex, multifactorial disease resulting from an interaction between environmental and genetic factors. A minority of patients form stones because of well defined systemic diseases. In the rest, who usually are otherwise well expected for stone formation, the pathogenesis of stone is not as clearly defined. Comprehensive metabolic evaluation has become an important aspect of the management of recurrent nephrolithiasis, yet the role of stone analysis is often neglected or perhaps underestimated. The purpose of this study is to evaluate the chemical composition of kidney and biliary stones in our patients in order to provide guidance in metabolic evaluation and medical diagnosis, therapeutic treatment and prevention of recurrence. We used infrared spectroscopic method (Perkin Elmer Infrared Spectroscopy) to analyze the chemical composition of 224 kidney stones passed spontaneously or removed surgically and 40 gallstones removed surgically in the »Mother Teresa« University Hospital Centre of Tirana. Of 224 kidney stones 62 % belong to male and 38% to female patients. Of infrared spectroscopic examinations of kidney stones 75.4% of results are calcium oxalate (CaOx) stones, 12.5% uric acid (UA) stones, 10.3% phosphate stones and 1.8% cystine stones. Of CaOx stones 67.4% are pure CaOx stones and 32.6% are mixed composition stones (CaOx mixed with UA or apatite). Of UA stones 82.1% are pure UA stones, 10.7% are UA stones mixed with ammonium urate and 7.2% are pure ammonium urate stones. Of phosphate stones 39.1% are of struvite composition, 26.1% are of carabapatite composition and 34.8% are of struvite composition mixed with apatite. The incidence of CaOx stones, UA stones and cystine stones is higher in men, while phosphate stones predominate in women. The chemical composition of 40 biliary stones examined with infrared spectroscopy is the following: 2.5% are pure calcium bilirubinate stones, 42.5% are pure cholesterol stones and 55% are mixed stones (cholesterol stones mixed with calcium bilirubinate, calcite, aragonite or apatite). Females predominate in biliary stones. Calcium stones are the most frequent kidney stones. Calcium stones, uric acid stones and cystine stones were found more frequently in males than in females. On the other hand, phosphate containing stones, very often called »infection stones«, were more frequent in female patients. Cholesterol stones predominate in gallstones examined by infrared spectroscopy. All types of gallstones are more frequent in women than in men. Stone analysis alone may provide guidance for therapeutic treatment and recurrence prevention.

Key words: kidney stone, gallstone, stone chemical composition, infrared spectroscopy

Introduction

Kidney stones (nephrolithiasis, renal calculi) are a concretion composed of crystalline components and organic matrix (1). Although the symptomatic presentations may be similar; the disorder is heterogeneous as to composition and aetiology.

Today, most urinary stones in patients in most countries are renal stones. Bladder stones are becoming less common, but still occur in children living in not industrialized part of the world. The incidence and prevalence rates of kidney stones may be affected by genetics, nutritional, and environmental factors. About 0.1–0.4% of the population is believed to have kidney

stones every year in the USA and Europe. About 2–5% of population in Asia, 8–15% in Europe and North America and 20% in Saudi Arabia develop kidney stones in their lifetime (2–6). Renal stones tend to recur, and the rate of recurrence is about 75% during 20 years (7).

Nephrolithiasis is a complex, multifactorial disease resulting from an interaction between environmental and genetic factors (7). A minority of patients form stones because of well defined systemic diseases. In the rest, who usually are otherwise well expected for stone formation, the pathogenesis of stone is not as clearly defined.

A specific diagnosis for every patients with kidney stones, may give very important information about the stone-formation mechanism and the pharmaceutical manner to prevent recurrent stone formation (8–10.) One of the most important elements which elucidate the stone formation mechanism are stone chemical composition analyses.

Material and Methods

We analyzed 224 kidney stones passed spontaneously or removed surgically from stone patients in the Urologic Surgery Service and 40 gallstones removed surgically in the General Surgery Service of Mother Teresa University Hospital Centre, of Tirana. Of 224 kidney stone patients, 85 are females and 139 males. Among gallstone patients there was a high prevalence of females (33 vs. 7).

The chemical composition of kidney and gallstones were determined by infrared spectroscopic (Perkin Elmer Infrared Spectroscopy) method using the potassium bromide technique. A 1–2 mg specimen is generally sufficient to obtain a good spectrum. If necessary this quantity can be reduced. Infrared spectroscopy is a physical method based on the property of atom groups, according their nature and their environment, to absorb infrared radiations of different wavelengths. The molecular composition and the crystal lattice influence the absorption and lead to a characteristic spectrum. Infrared spectroscopy is a very convenient for analysis of kidney and gallstones because the equipment is not expensive, the time required for analysis is short (10–15 minutes), a small amount of sample is required, and many components (five, six and even seven) may be detected in a single spectrum.

Results

The prevalence of kidney stones in our stone patients resulted in the finding that male patients predominate (62% vs. 38%). The composition of 224 kidney stones is as follows: The most frequent type was calcium containing stones (75.4%), followed by uric acid stones (12.5%), phosphate stones (10.3%), and cystine stones (1.8%).

The incidence of calcium containing stone, uric acid stone and cystine stone was higher in man, while phosphate stones predominated in women. Pure calcium oxalate stones (67.5%) were the most frequent calcium containing stones, followed by calcium oxalate mixed with apatite (21.9%) and calcium oxalate mixed with uric acid (10.7%). All types of calcium containing kidney stones were found more frequently in males than in females.

Calcium oxalate monohydrate stones (60.5%) were the most frequent pure calcium containing kid-

ney stones. This fact suggests that hyperoxaluria is particularly frequent in our stone patients.

Uric acid dihydrate stones (42.9%) were the most frequent uric acid stones. Male sex predominated in all types of uric acid containing kidney stones.

Struvite stones were the most frequent phosphate stones (39.1%), followed by struvite mixed with carbapatite stones (34.8%) and carbapatite stones (26.1%). All kinds of phosphate stones, usually named »infectious« stone, were more often found in females than in males.

A high prevalence of studding gallstones we evidence in females (82 % vs. 18 %). The most frequent type were mixed stones (cholesterol containing stones mixed with calcium bilirubinate, calcite, aragonite or apatite), followed by cholesterol stones and calcium bilirubinate stones.

Discussion

Today the need of studying the chemical composition of kidney and gallstones passed spontaneously or removed surgically, is necessary more and more. The data completed with a laboratory evaluation of metabolic disturbance for every stone patients may clarify the nature of stone aetiopathology, and will provide guidance for therapeutic treatment and prevention of recurrence.

Nowadays, different laboratories use chemical or physical methods in analyzing kidney and gallstone chemical compositions. But chemical methods sometimes give false-positive or false-negative results, have not the same sensitivity to all reactions, give no information about crystalline forms, require large quantities of samples and can not detect rare drug-induced or metabolic lithiasis (stone composed of triamterene, silica, xanthine, 2,8-dihydroxy-adenine). Physical methods are more interesting because they are more selective and sensitive, providing sufficient data on the structure and chemical composition of the stone (11–13).

Infrared spectroscopy, a physical method used by us in the evaluation of 224 kidney and 40 gallstones chemical composition, is a very convenient method because the time required for any analysis is short (10–15 minutes); small sample is required (1–2 mg) and numerous samplings can be made; amorphous, protein, oily, or viscous compounds give a specific spectrum; many components can be detected in a single spectrum; can detect rare type of lithiasis (11).

Calcium containing stones (75.4%) predominate among kidney stones, that we analyzed. Males were more affected by calcic, uric and cystine stones, while phosphate stones predominate in females. The data correspond with other studies which report the calcium containing stones more frequently among kidney

stones (14–16). The reason, why male sex is more affected by calcic and uric stones, may be in risk factors like hypercalciuria and hyperuricuria which prefer male sex and have a very important role in initial crystallization, crystal aggregation. Infection of the urinary tract, which is more common in women plays a crucial role in phosphate stone formation.

A high prevalence of calcium and uric acid containing stones in our patients (generally metabolic disorder stones) elucidate the idea that compositional stone analysis should be an integral part of metabolic evaluation of patients with nephrolithiasis.

A high frequency of calcium oxalate monohydrate calculi in our patients, suggest that hyperoxaluria is particularly frequent and may be one of the important cause of calcium oxalate stone formation.

There is a high frequency of cystine stones (1.8%) compared with other studies in the world. This may be as a consequence of limited number of kidney stones studied by us.

A high prevalence of mixed gallstones (cholesterol stones mixed with calcium bilirubinate, calcite, aragonite or apatite) among our patients elucidates the idea that gallstones due to infection rather than supersaturation (17–20) are present in our study. Of course the limited number of cases needs to be increased.

Conclusion

Every kidney and gallstone that is surgically removed or spontaneously expelled must be analyzed with appropriate techniques for early detection of any lithogenic factors. If such factors are not detected and eliminated renal function can be impaired.

Infrared spectroscopy may be one routine analyses procedure, which can be used in no specialized laboratories, providing enough precise and reliable data on the composition of the stones. These accurate conclusions may provide guidance for therapeutic treatment and recurrence prevention.

INFRACRVENA SPEKTROSKOPIJA KAMENACA KOD BUBREŽNOG I BILIJARNOG OBOLJENJA

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Kratak sadržaj: Nefrolitijaza je kompleksno, multifaktorijalno oboljenje koje je posledica interakcije između spoljašnjih i genetskih faktora. Kod jednog broja pacijenta formiraju se kamenci usled dobro poznatih sistemskih oboljenja. Kod ostalih, patogeneza formiranja kamenaca nije jasno definisana. Iz ovog razloga sveobuhvatno ispitivanje nefrolitijaze, mada u priličnoj meri potcenjeno, je veoma značajno. Svrha ovog rada je bila da se ispita hemijski sastav bubrežnih i bilijarnih kamenaca radi metaboličke evaluacije i medicinske dijagnoze, terapeutskog tretmana i sprečavanja ponovne pojave. Korišćena je infracrvena spektroskopija za analizu hemijskog sastava 224 bubrežna kamenca koji su spontano izbačeni ili uklonjeni hirurški i 40 žučnih kamenaca uklonjenih hirurškim putem u Univerzitetnoj bolnici Majka Tereza u Tirani. Od 224 bubrežna kamenca, 62% je pripadalo muškarcima a 38% ženama. Infracrvena spektroskopija je pokazala da je 75,4% kamenaca bilo kalcijum oksalatnih, 12,5% uratnih, 10,3% fosfatnih i 1,8% cistinskih. U daljem ispitivanju pokazan je njihov detaljniji sastav. Incidenca kalcijum-oksalatnih, uratnih i cistinskih kamenaca bila je češća kod muškaraca, dok su se fosfatni kamenci pretežno javljali kod žena. Utvrđeno je da je sastav bilirajnih kamenaca bio 2,5% čisto kalcijum bilirubinatih, 42,5% čisto holesterolskih i 55% je bilo mešoviti (holesterolski kamenci sa kalcijum bilirubinatom, kalcitom, aragonitom ili apatitom). Žene su pretežno imale bilijarne kamence. Utvrđeno je da su kalcijum kamenci najčešći bubrežni kamenci, a kalcijumovi kamenci, uratni i cistinski su češće bili zastupljeni kod muškaraca nego kod žena. S druge strane, fosfatni kamenci, koji se često označavaju kao »kamenci infekcije« bili su češći kod žena. Holesterolski kamenci su bili dominantni kod žučnih kamenaca; svi nađeni tipovi bili su češći kod žena nego kod muškaraca. U zaključku se može reći da analiza kamenaca može da obezbedi terapijski tretman i pravovolanju prevenciju kod ovakvih pacijenata.

Cljučne reči: bubrežni kamen, žučni kamen, hemijski sastav kamenaca, infracrvena spektroskopija

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