Efficacy of Hounsfield Unit of CT in Prediction of the Chemical Composition of Urinary Stones

Thesis

Submitted for Partial Fulfillment of Master Degree in Urology

By

Ahmed Salah Mahmoud Ahmed Shehata
M.B.B.Ch 2014

Under supervision of

Prof. Dr. Mohamed Rafik El-Halaby
Professor of Urology
Faculty of Medicine - Ain Shams University

Assist. Prof. Dr. Ahmed Mohamed Saafan
Assistant Professor of Urology
Faculty of Medicine - Ain Shams University

Faculty of Medicine
Ain Shams University
2020

Acknowledgment

First and foremost, I feel always indebted to **ALLAH,** *the Most Kind and Most Merciful.*

I'd like to express my respectful thanks and profound gratitude to **Prof. Dr. Mohamed Rafik El-Halaby,** *Professor of Urology Faculty of Medicine - Ain Shams University for his keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.*

I am also delighted to express my deepest gratitude and thanks to **Assist. Prof. Dr. Ahmed Mohamed Saafan**, *Assistant Professor of Urology Faculty of Medicine - Ain Shams University, for his kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work.*

Ahmed Salah Shehata

List of Contents

Title	Page No.

List of Tables

List of Figures

Fig. No.	Title	Page No.

List of Figures Cont...

Fig. No.	Title	Page No.

List of Figures Cont...

List of Abbreviations

Abb.	Full term
AGT	Glyoxylate aminotranserase
AH	Absorptive hypercalciuria
AH2	Absorptive hypercalciuria type 2
AmU	Ammonium urate
BMI	Body mass index
BRS	Brushite
C O	Carbonyl
CAP	Carbonate apatite
COD	Calcium oxalate dehydrate
COM	Calcium oxalate monohydrate
CT	Computed tomography
FTIR	Fourier transform IR
GRHPR	Glyoxylate reductase / hydroxypyruvate reductase
HHRH	Hereditary hypophosphatemic rickets with hypercalciuria
HIV	human immunodeficiency virus
HU	Hounsfield unit
IRS	Infrared spectrometry
IVU	Intravenous urography
LDH	Lactate dehydrogenase
MAP	Magnesium ammonium phosphate
MET	Medical expulsive therapy
NCCT	Noncontrast CT
PCNL	Percutaneous nephrolithotomy
PH I	Primary hyperoxaluria type I
PH	Primary hyperoxaluria
PLS	Partial least square
PTH	parathyroid hormone

List of Abbreviations Cont…

Abb.	Full term
RCTs	Randomized controlled trial
UA2	Uric acid dehydrate
UAuric	Acid anhydrate
XDH	Xanthine dehydrogenase

INTRODUCTION

Urolithiasis is a prevalent disease in developed countries where its prevalence ranges between 4% and 20%. Determination of the chemical composition of urinary stones helps in perioperative evaluation, treatment and prophylaxis ***(Jepperson et al., 2013).***

Urolithiasis is a worldwide problem, affecting all geographical, cultural and racial groups. The lifetime risk is 10-15% in the developed world but can be as high as 20-25% in Middle East. Nephrolithiasis is largely a recurrent disease with a relapse rate 50% in 5-10 years and 75% in 20 years. CT is now recommended by many as the initial diagnostic imaging technique in patients with suspected renal or ureteric calculi as unenhanced CT has sensitivity and specificity of 97% and 96% respectively for detecting urolithiasis. CT is considered as the reference standard method in for diagnosing urolithiasis, but it is also a major source of exposure to radiation during medical imaging ***(El-Assmy et al., 2013)***

The radiographic diagnosis of cystine or uric acid stones can help in both management of symptomatic stones and prevention of stones growth. Uric acid stone formers can be treated with urinary alkalinization and/or urease inhibitors, and cystine stone formers can undergo medical therapy with thiol-binding agents and urinary alkalinization. Fortunately, many studies have correlated non contrast CT findings to stone composition, which helps in selecting the most appropriate therapeutic modality ***(Torricelli et al., 2014).***

Although clinical guidelines include the need to analyze the calculi, a little information were mentioned regarding the recommended methodology to be used, however; infrared spectrometry (IRS) and x ray diffraction are the most mentioned techniques ***(Straub et al., 2005; et al., 2001).***

Urinary stone analysis can be done through multiple methods, chemical analysis has been traditionally used most widely due to its ease and low cost even if this technique is time consuming and necessitates large stone samples. Moreover, the various hydration degrees cannot be determined through chemical methods and chemical methods cannot distinguish between similar crystalline entities, e.g. Calcium oxalate monohydrate vs Calcium oxalate dihydrate, Apatite vs. Brushite, etc. Therefore, chemical methods have repeatedly proved to be unreliable in numerous quality control programs, with error rates in identifying certain components up to 90% ***(Basiri et al., 2012).***

Infra-Red spectrometry is based on interaction of infrared light with the covalent bonds of the compounds present in calculus, leading to the emergence of some characteristic bands that make their identification possible. Its main advantages are that it can be applied on very small samples (less than 4 mg) and it allows the identification of both crystalline and amorphous substances (proteins, amorphous phosphates, lipids, etc.). But the need for experience in the identification of the spectra and the lack of other applications in routine laboratories mean that Infra-Red spectrometry is available at very few centers. The Infra-Red spectrometry has a high analytical quality and practicability, and is considered as a very useful methodology in the study of calculus ***(V. K. Singh & Rai, 2014).***

There is a fact of an increasing incidence of urolithiasis including new and recurrent urinary calculi, indicating that the disease has a high level of both acute and chronic morbidity. There is a considerable variation in the rates of urolithiasis based on climate, geography, diet, fluid intake, gender, occupation, genetics, and age. Therefore, understanding the epidemiology of stone disease is the cornerstone for improving patient care and possibly prevention ***(Sorokin et al., 2017).***

AIM OF THE WORK

To make a reliable correlation between the chemical composition of the urinary calculi and its Hounsfield unit on CT scan, upon which we can depend on it for prediction of the type of the urinary calculi.

Chapter 1

EPIDEMIOLOGY OF URINARY CALCULI

Nephrolithiasis is a highly prevalent disease all over the world with rates ranging from 5–9% in Europe, 7 to 13% in North America,, and 1–5% in Asia. There is conclusive evidence for an increasing incidence of stones in the United States with recent data stating an overall prevalence of stone disease in 8.8% of the population (men 10.6%, women 7.1%) which is estimated as an increase from the 5.2% prevalence of kidney stone disease from 1988 to 1994. There was a documentation of this rise over a 40-year period in Japan where the estimated annual incidence of upper urinary tract stones in 2005 was 134.0 per 100,000 (192.0 in men and 79.3 in women) compared with 54.2 per 100,000 in 1965. The annual incidence has increased in all age groups except during the first three decades of life, taking into consideration that the peak age for both men and women has also increased ***(Sorokin et al., 2017).***

Gender:

Adult men are noticed to be more commonly affected by urolithiasis than adult women. It is estimated that men are affected two to three times more frequently than women, this percentage was calculated according to multiple indicators including inpatient admissions, outpatient clinic visits, and emergency department visits ***(Strope et al., 2010).***

However, there has been some evidence of a narrowing of the gender gap which may be linked to diet changes and increase in metabolic syndrome including rates of obesity and diabetes ***(Sorokin et al., 2017).***

Also, the lower incidence of urolithiasis in females compared to males has been attributed to the protective effect of estrogen against formation of stones in premenopausal women, due to enhanced renal calcium reabsorption and reduced bone resorption ***(Bansal et al., 2013).***

Age:

The incidence of stones varies by age with low incidence in childhood and the elderly and peaks in the fourth to sixth decades of life ***(Saigal et al., 2005).***

There are differences in stone composition in different age groups. For example, calcium oxalate dihydrate (COD) stones are more common in young stone former in both sexes. In Europe, stone composition differs and affected by age and gender ***(Knoll et al., 2010).***

Race:

Unfortunately, the data comparing urolithiasis differences between races within one country were only