Urolithiasis is a common urologic disease. Stones may occur in the kidney, ureter, or urinary bladder. We collected 1,000 stone samples in the subtropical area of southern Taiwan. Stone components were analyzed by Fourier transform infrared spectroscopy. Mixed components of calcium oxalate and calcium phosphate were the most common form of stones (52.3%), followed by calcium oxalate (27.8%) and calcium phosphate (9.3%). Uric acid stones accounted for 7.6%. Magnesium ammonium phosphate stones accounted for 3.0%. Only one cystine stone was found. In the study of urinary stone formation mechanism and prevention of recurrent urolithiasis, knowing the stone composition is important.

**Key Words:** infrared spectroscopy, stone analysis, urolithiasis (*Kaohsiung J Med Sci* 2007;23:63–6)

**Materials and Methods**

From 2003 to 2005, 1,000 urinary calculi were collected in two hospitals in subtropical southern Taiwan and were analyzed by infrared spectroscopy. Most of the stones had been passed spontaneously. Some were collected during surgical manipulation, including ureterorenoscopic lithotripsy, percutaneous nephrolithotomy, cystolitholapaxy, or open surgery.

A Perkin–Elmer R×1-FTIR Fourier transform infrared spectrophotometer was used. Spectra were obtained by KBr disc technique. KBr itself had no absorption. Samples to be analyzed were thoroughly ground with an agate pestle and mortar and intimately mixed with KBr power at a sample concentration of approximately 1% and their spectra were obtained in the KBr matrix. Suitable discs were obtained for analysis, prepared by ensuring adequate grinding of the sample, dryness of the KBr power, and application of sufficient pressure during pressing of the disc.
The FTIR instrument is an automatic recording double-beam infrared spectrophotometer that measures and records percent transmittance of a sample at any frequency in the infrared zone between 4,000 and 450 cm wave number. Components of the stone are evaluated according to the wave that is absorbed [6].

**RESULTS**

The overall male to female ratio was 2.93. The age distribution ranged from 9 to 90 years with a mean of $52.5 \pm 13.5$ years. The Table shows the percentage of various stone components in the whole series of 1,000 stones. Mixed components of calcium oxalate and calcium phosphate were by far the most common form (52.3%). Calcium oxalate, including monohydrate form (whewellite) and dihydrate form (weddellite), was the second most common form (27.8%), and the third most common form was calcium phosphate (9.3%). Uric acid components accounted for 7.6% of all stones. Struvite stones accounted for 3.0%. Only one cystine stone was found, occurring in a child (Table).

**DISCUSSION**

Urolithiasis affects about 10% of the worldwide population and is increasing in prevalence. The presence of stones may be asymptomatic, symptomatic, or discovered when the patient suffers complications. Recurrences are common with 30–50% of men, with the formation of another stone occurring within 5 years of first stone incident. To decrease the likelihood of stone recurrence, patients are routinely advised to increase their urine volume by increasing their fluid intake [7].

Stone analysis is recommended during the evaluation of patients with nephrolithiasis [8,9]. In 1800, William Herschel discovered infrared radiation. In 1955, Beischer published his observations on the analysis of renal stones by infrared spectroscopy. According to studies by Davies and Modlin [6], infrared is the portion of the electromagnetic spectrum that extends beyond the visible into the microwave region. It is measured in units of frequency or wavelength. All molecules are made of atoms held together by chemical bonds. These atoms vibrate with respect to each other, the bonds acting much like springs connecting the atoms. Each molecule has its own specific set of vibration frequencies, but different molecules have different sets of vibrations. The frequencies of these vibrations are in the same range as the infrared frequencies of electromagnetic radiation. Infrared instruments measure the vibrational spectrum of a sample by passing infrared radiation through it and recording which wavelengths have been absorbed and to what extent. The recorded spectrum is a plot of the transmittance of the sample versus the frequency (or wavelength) of the radiation. This spectrum is a fundamental property of the molecules and can be used to characterize the sample. Infrared spectroscopy has been used extensively for the identification of organic and inorganic compounds, since the infrared spectrum of a chemical compound is perhaps its most characteristic physical property and is in effect a fingerprint of the constituent materials. By matching the infrared spectrum of an unknown material with that of a known one, proof of identity can be established.

The purpose of this study was to analyze the components of 1,000 urolithiasis with the hope of applying the data obtained to the study of the etiology of stone formation, treatment of stones, and the prevention of stone recurrence.

Knowing the composition of a urinary stone can be useful in the selection of stone treatment. For example, calcium oxalate dihydrate and struvite stones are more amenable to disintegration by extracorporeal shock wave lithotripsy than are those composed of cystine [10]. In some instances, identification of particular stone composition may yield the underlying metabolic disturbance, such as the association between magnesium ammonium phosphate stones and chronic infection of the urinary tract with a urea-splitting organism [11]. For more common stones, which are usually composed of calcium oxalate with or without calcium phosphate, the diagnostic value of stone composition is less apparent [8]. Renal tubular acidosis and primary hyperparathyroidism are associated more with

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
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<tbody>
<tr>
<td>CaOx + CaP</td>
<td>52.3</td>
</tr>
<tr>
<td>CaOx</td>
<td>27.8</td>
</tr>
<tr>
<td>CaP</td>
<td>9.3</td>
</tr>
<tr>
<td>Uric acid</td>
<td>7.6</td>
</tr>
<tr>
<td>Struvite</td>
<td>3.0</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.1</td>
</tr>
</tbody>
</table>
calcium phosphate stones than with calcium oxalate stones [12]. Uric acid stones are associated with gouty diathesis.

Pak et al [12] reported that the most common form of kidney stones were calcium oxalate (74.8%), mixed calcium oxalate–calcium apatite (34.8%), calcium phosphate alone (10.5%), uric acid stones (5.8%), infection stones (3.9%), and cystine stones (2.7%). In this study, we found more mixed calcium oxalate–calcium phosphate stones, fewer calcium oxalate stones, fewer cystine stones, and a similar incidence of calcium phosphate, uric acid, and infection stones. Hsu et al [5] reported that urinary stone patterns in Taiwan are now similar to those of developed Western countries since the lifestyle and dietary habits of Taiwanese have been dramatically westernized. However, some distinctions were apparent among calcareous stones by stone analysis.

Medical diagnosis is important in the prevention of stone recurrence. Most patients, however, will require a metabolic evaluation to determine the underlying disorder in addition to stone analysis.

REFERENCES

南台灣1,000例尿路結石分析

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尿路結石是一種常見的泌尿系統疾病。結石可能發生在腎臟、輸尿管或膀胱。本研究收集兩年來位處亞熱帶地區的1,000例結石樣本，以傅立葉轉換紅外線光譜儀分析結石成份。結果顯示：草酸鈣與磷酸鈣混合型結石最多，佔52.3%；草酸鈣結石第二，佔27.8%；磷酸鈣結石佔9.3%；尿酸結石佔7.6%；磷酸鈦鎂結石佔3.0%；只發現一例cystine結石。瞭解尿路結石成分對結石的形成機轉及再發性結石的預防都有重要的幫助。

關鍵詞：紅外線結石分析，結石分析，尿路結石

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