Original Article

Cost Assessment of Initial Radiological Modalities for Evaluation of Adult Patient with Asymptomatic Microscopic Hematuria at Thammasat University Hospital

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Abstract

Introduction: Asymptomatic Microscopic Hematuria (AMH) is highly prevalent. There is controversy regarding the radiologic evaluation in the patient with AMH. The choice of diagnostic evaluation for patient with AMH has broad clinical and economic implication. As of now, no study aims to determine worthiness of each radiologic evaluation.

Objective: To estimate the capability and cost per positive unit for abnormality detection of 5 radiologic evaluations in patient with AMH.

Methods: The detection rate of four diagnostic approaches (Plain KUB radiography, intravenous pyelography (IVP), ultrasound (US) and, unenhanced computed tomography) were evaluated and compared to the reference enhance computed tomography (CT). Cost per positive unit was determined by number of abnormality detection in all 5 radiological evaluations.

Results: The KUB US has highest detection rate (51.2%). When comparing others radiologic evaluation with enhanced CT, there is no significant difference on their performance in lesion detection. In male patients, US has least cost per positive unit (1,050 Bahts) and highest detection rate (66.7%). While plain KUB radiography has least cost per positive unit (440 Bahts) in female patients with detection rate between plain KUB radiography and US are very close (28.3% to 37.8%).

Conclusions: IVP is not a suitable initial investigation for AMH, according to its low detection rate and high cost per positive unit. US is the most useful tool in KUB abnormality detection. Plain KUB radiography has the lowest cost per positive unit in our study.

Keywords: Asymptomatic microscopic hematutia, Radiological evaluations, Cost wound

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Introduction

Asymptomatic microscopic hematuria (AMH), the presence of 3 or more red blood cells on urinalysis in the absence of genitourinary symptoms, is highly prevalence.[1-4] It is often found incidentally as a result of routine examination in patient without urinary tract symptoms.[2] There is controversy regarding the radiologic evaluation in the patient with AMH.[2] Others have sought alternative radiologic evaluation for AMH, predominantly driven by the fact that most evaluation for AMH return negative results for abnormality. No international consensus guideline is applied in patient with AMH. The choice of diagnostic evaluation for patient with AMH has broad clinical and economic implication.[1] The cost must be weighed against the relative of negative finding. Despite the economic burden of AMH evaluation, there have been few studies evaluating cost-effectiveness, which have focused on detected KUB disorder. Enhanced computed tomography is the most reliable to for detection of KUB disorder.[5-7] As for now, no study aims to determine worthiness of each radiologic evaluation. Moreover, no Thai study had ever done before on this related matter. This study, we determine worthiness of each initial radiologic evaluation according to their capability on abnormality detection and price. Radiologic evaluation included plain KUB radiography, intravenous pyelography (IVP), ultrasound (US), unenhanced, and enhance computed tomography (CT).

Objective

To estimate detection rate and cost per positive unit for abnormality detection for 5 initial radiologic evaluations in patient with AMH.

Methods

This retrospective study was approved by ethics committee in our institute.

Data collection

Four hundred and eighty-two adults, age more than 18 years, with microscopic hematuria who had radiologic evaluation in Thammasat University Hospital between January 1, 2013 and November 30, 2017 were collected from radiology information system (Envision.net). We included patients who had no KUB disease or symptom. Patients whose urinalysis result did not meet microscopic hematuria criteria (RBC > 3 cell/HPF) were excluded. Patient who had incomplete medical record were also excluded. Total 306 patients were enrolled in our study. First radiologic evaluation for AMH were encountered for analysis. The standard radiologic evaluation included plain KUB radiography, IVP, US, unenhanced and enhanced CT were performed. Demographic data, included age and sex, were collected.

All images were reviewed by two radiologists (K.T. with 11-year experience and W.L. with 9-year experience). Positive radiologic evaluation was assigned when there was KUB abnormality which potentially cause hematuria or need further investigation. The abnormalities were classified into KUB tumor and non-tumor groups. Non-tumor group was subdivided into stone and non-stone groups.

Statistical analysis

Pearson's Chi-squared test was used for comparison of the capability on abnormality detection of 4 standard radiologic evaluation included plain KUB radiography, IVP, US, and unenhanced CT, using enhanced CT as the reference.

Cost analysis

Cost of each radiologic evaluation in Thammasat University Hospital are presented in Table 1. Any health coverage or discounting was not considered. Cost per positive unit of each radiologic evaluation were calculated, using the following formula.

$$\text{Cost per positive unit} = \frac{\text{Total cost of each radiologic evaluation*}}{\text{No. of positive cases in each radiologic evaluation}}$$

* Total cost of each radiologic evaluation = cost of each radiologic evaluation x total number of cases in each radiologic evaluation

Table 1 Cost data used in cost per unit analysis

Modalities	Cost (Baht)
Plain KUB Radiography	220
Intravenous Pyelography (IVP)	2,000
Ultrasonography (US)	700
Unenhanced Computed Tomography	5,500
Enhanced Computed Tomography	7,000

Results

Demographic data

Age of our study population ranges from 18 to 94 years. The mean age is 65 years. Age range of 60 - 69 years has the highest prevalence of AMH. Male patients' age is ranging from 23 years to 90 years. The male mean age is 56.5 years and age 60 - 69 years is the highest prevalence group. For female patients, ages range is from18 to 94 years. The female mean age is 56 years and age 60 - 69 years is also the highest prevalence group.

KUB abnormality detection

Of the 306 patients, only 121 patients have KUB abnormality on their first radiologic evaluation. Details of KUB abnormality in 121 patients are displayed in Table 2. Almost of all KUB abnormality is non-tumor lesions (98.35%). Only two patients have KUB neoplasm, renal cell carcinoma in 72-year-old woman and bladder cancer in 90-year-old man. Both neoplasms were detected by KUB ultrasound. For non-tumor KUB abnormality, KUB stone is the most common disease (37.2%). KUB stone can be detected in all radiologic evaluation (42.2% by plain KUB radiography, 8.9% by IVP, 46.7% by US and 2.2% by enhanced CT). Number of positive studies between male and female patients are very similar.

The result of percentage of positive lesions detected in 5 radiologic evaluations are displayed in Table 2. The plain KUB radiography has lowest detection rate, only 29 patients from 79 patients (24.1%). While US has highest detection rate, 86 patients from 168 patients (51.2%). Nevertheless, when we compared others radiologic evaluation with enhanced CT. There is no significant difference of their performance on lesion detection (Table 3).

Table 2 Number of positive studies in patients with AMH

Modalities	Number of patients										
	Total number	Total Positive Number (%)	Tumor			Non-Tumor					
						Stone			Non-Stone		
			Male	Female	Total	Male	Female	Total	Male	Female	Total
KUB Radiography	79	19 (24.1)	0	0	0	5	14	19	0	0	0
IVP	49	12 (24.5)	0	0	0	1	3	4	2	6	8
US	168	86 (51.2)	1	1	2	13	8	21	38	25	63
Unenhanced CT	3	1 (33.3)	0	0	0	0	0	0	1	0	1
Enhanced CT	7	3 (42.9)	0	0	0	1	1	1	1	1	2
Total	306	121 (39.5)	1	1	2	20	25	45	42	32	74

Table 3 Comparison the performance of radiologic evaluation of patients with AMH

Modalities		Number	Percentage	*P*-value
KUB Radiography	Negative	60	75.95	.522
	Positive	19	24.05	
IVP	Negative	37	75.5	.569
	Positive	12	24.5	
US	Negative	82	48.8	.963
	Positive	86	51.2	
Unenhanced CT	Negative	2	66.7	.788
	Positive	1	33.3	

Note: Statistical significance *P*-value < .05

Expenditures

All calculated costs for AMH evaluation are shown in Table 4. Only US has total cost for positive studies less than negative studies. Total cost for negative IVPs is three times more than positive studies. Plain KUB radiography has the cheapest cost per unit, followed by US and IVP. But cost per positive unit of IVP is much higher than plain KUB radiography and US (8,166.67 Bahts to 914.74 Bahts and 1,367.44 Bahts).

Table 4 Calculated costs unit of each modality in patients with AMH

Modalities	Total Studies	Total Positive Studies	Total cost for positive cases	Total cost for negative cases	Cost per Positive unit (Baht)
KUB Radiography	79	19	4,180	13,200	914.74
IVP	49	12	24,000	74,000	8,166.67
US	168	86	60,200	57,400	1,367.44
Unenhanced CT	3	1	5500	11,000	16,500
Enhanced CT	7	3	21,000	28,000	16,333.33

Cost per positive unit for male and female patients are displayed in Table 5. In male patients, US has the least cost per positive unit. While plain KUB radiography has the least cost per positive unit in female patients. In male patients, US also has highest detection rate (66.7 %). While in female patients, detection rate between plain KUB radiography and US are very close. But US is much more expensive than plain KUB radiography (1852.94 to 778.46 Bahts).

Table 5 Cost per positive unit of each modality in male and female with AMH

Modalities	Gender	Total Studies	Total Positive Studies	Percentage of Positive Studies	Cost per Positive unit (Baht)
KUB Radiography	Male	33	6	18.2	1,210
	Female	46	13	28.3	778.46
IVP	Male	12	3	25	8,000
	Female	37	9	24.3	8,222.22
US	Male	78	52	66.7	1,050
	Female	90	34	37.8	1,852.94
Unenhanced CT	Male	2	1	50	11,000
	Female	1	0	0	-
Enhanced CT	Male	3	2	66.7	10,500
	Female	4	1	25	28,000

Cost per positive unit for younger patients (< 60 years) and older patients (≥ 60 years) are displayed in Table 6. In both groups, plain KUB radiography has the least cost per positive unit (1,072.5 Bahts in younger patients and 800 Bahts in older patients). In older patient group, US has very high detection rate (61.9 %). In younger patient group, US has a little higher detection rate than plain KUB radiography but cost positive per unit of US is 839-baht more expensive than plain KUB radiography. In older male patient group, US is the cheapest radiologic evaluation for AMH which also has an impressive detection rate (75.9 %). While in older female patient group, US is twice more

expensive than plain KUB radiography. Furthermore, detection rate of US in older female patient group is only 44.2%. Cost per positive unit of all radiologic evaluation in older male and female patients are demonstrated in Table 7.

Table 6 Cost per positive unit of each modality in patients with age ≥ 60 years old and < 60 years old

Modalities	Age (years old)	Total Studies	Total Positive Studies	Percentage of Positive Studies	Cost per Positive unit (Baht)
KUB Radiography	≥ 60	40	11	27.5	800
	< 60	39	8	20.5	1,072.5
IVP	≥ 60	21	7	33.3	6,000
	< 60	28	5	17.9	11,200
US	≥ 60	97	60	61.9	1,131.67
	< 60	71	26	36.6	1,911.54
Unenhanced CT	≥ 60	1	0	0	-
	< 60	2	1	50	11,000
Enhanced CT	≥ 60	4	2	50	14,000
	< 60	3	0	0	-

Table 7 Cost per positive unit of each modality in male and female patients with age ≥ 60 years old

Modalities	Age (years old)	Total Studies	Total Positive Studies	Percentage of Positive Studies	Cost per Positive unit (Baht)
KUB Radiography	Male	14	3	21.4	1,026.67
	Female	26	8	30.8	715
IVP	Male	5	2	40	5,000
	Female	16	5	31.3	6,400
US	Male	54	41	75.9	921.95
	Female	43	19	44.2	1,584.21
Unenhanced CT	Male	1	0	0	-
	Female	1	0	0	-
Enhanced CT	Male	3	1	33.3	21,000
	Female	1	1	100	7,000

Discussion

AMH is a common clinical urologic problem is general practice. Many etiologies can cause AMH including urinary tract infection, benign prostatic hyperplasia, urinary calculi, bladder cancer, renal cystic disease, renal parenchymal disease, kidney cancer, prostate cancer, and urethral stricture disease.[8,9] Recently, no international consensus practice guideline for AMH investigation is established. Many radiological modalities have been used for initial evaluation. Referring physician's choice mostly depends on patient's risk for KUB malignancy such as gender, age and history of smoking. Patient's socioeconomic status is also another condition that is used for this consideration. The plain KUB radiography is the most widely used initial modality because of its cheapness, availability and short time of examination. But it has very low sensitivity and specificity. The IVP has better visualization of the KUB system than plain radiography because of using of intravenous contrast material. But it still has low sensitivity and specificity,

particularly with KUB tumor. The US is known to be a sensitive imaging study. It can be done bed-side and has no radiation exposure. However, the US's capability is limited by operator's experience. The CT has increasing use for investigation of KUB abnormalities, owing to its high sensitivity, specificity and accuracy, particularly KUB stone and malignancy. The unenhanced CT can be used in patient who is suspicious for stone disease. The enhanced CT is usually used in patient who has risk for malignancy. Nevertheless, CT has highest radiation exposure and more expensive.

In Thailand, IVP is one of the most common radiologic evaluation for AMH. In our study, IVP surprisingly has highest cost per positive unit with very low detection rate (8,166.67 Bahts and detection rate of 24.5%). It is obvious that IVP is not a suitable initial investigation for AMH. The Canadian urological association recently published guideline for AMH in 2009.[2] The guideline recommended US and urine cytology for patients who has hematuria without finding of glomerular disease. The study of Halpern JA, et al. also stated that renal US and cystoscopy is the most cost-effective method of evaluation of AMH.[1] However, this study used United States' cost input for analysis. Price of radiologic evaluation can vary from country to country. Our study used cost input, based on price in our hospital which were regulated by Comptroller General's department. Our study also found that US is the most useful tool in detection of KUB abnormality. Even Its cost per positive unit is not cheapest, but it is around 400-baht more expensive than plain KUB radiography (the cheapest one).

Male patients have predominant incidence in many diseases that can cause hematuria such as stone, renal cell carcinoma and urothelial cell carcinoma.[10-13] If the gender is considered in cost analysis. We found that US has the cheapest cost per positive unit and highest detection rate. So that, US should be an initial radiological evaluation for male patient with AMH. In female patients, detection rate between plain KUB radiography and US is very similar but cost per positive unit of plain KUB radiography is much cheaper than US. The plain KUB radiography seems to be a proper initial radiologic evaluation for female patients.

Study of Sultana SR, et al.[14] showed that in older patients with higher incidence rate of KUB malignancy need full urological investigation. Our study shows highest detection rate from US but its cost per positive unit is a bit higher (around 300 Bahts) than Plain KUB radiography. If gender is considered in older patients, US will have the cheapest cost per positive unit with highest detection rate in older male patient group. In contrast with older female patient group, cost per positive unit of US is twice more expensive than plain KUB radiography but the detection rate is only 10% higher. So, we think that US is the most suitable initial investigation for older male patients. While, plain KUB radiography might be more proper for older female patients.

There are many limitations in our study. First of all, our study is retrospective study which has selection bias. Very small population in this study effects and limits statistical analysis. These cause limited data to estimate the precise national expenditures for national cost savings associated strategies. KUB tumor is the most significant lesion that cause hematuria. Our study has very small sample of KUB tumor which also effect the result. Number of CT study is also very small while CT is the most reliable radiological evaluation of the KUB system. However, CT is not a routine initial evaluation for nowadays practice. Last, we did not consider the possibility of improper collection of the urinalysis in our study. This may affect the true incidence of hematuria and abnormality detection rate by radiologic study. The dedicated prospective study on cost-effectiveness of AMH investigation, including radiologic, endoscopic and all laboratory examination, is needed.

In conclusion, the study suggests that IVP is not an appropriate initial investigation for AMH, according to low detection rate and high cost per positive unit. US is the most useful tool in KUB abnormality detection. Plain KUB radiography has the lowest cost per positive unit in our study. However, dedicated prospective study on cost-effectiveness of AMH investigation, including radiologic, endoscopic and all laboratory examination, is necessary.

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