

# A Case Study of The Role of Ureter Tracking Reconstruction in Clinical Urology CT Scan Examination of Kidney Stones in the Radiology Installation of RSUD dr. Loekmono Hadi Kudus

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## Abstract

This study aims to determine the clinical urology CT scan procedure for kidney stones, analyze the justification for employing ureteral tracking reconstruction, and evaluate the ideal slice thickness for achieving accurate diagnostic images. This research employed a descriptive qualitative methodology utilizing a case study technique in the Radiology Department of RSUD (Regional General Hospital) dr. Loekmono Hadi Kudus. The subjects comprised of three radiographers, one radiologist, one referring physician, and three CT scan images of the urology. Data was obtained through observation, interviews, documentation, and literature review. The data were subsequently studied through reduction, presentation, discussion, and conclusion formulation. The examination was conducted without any specific preparation, merely by consuming 500-750 ml of water and refraining from urinating. The patient was placed in a supine position, feet-first, with arms elevated above the head, exposing the area from the xiphoid process to the symphysis pubis. A 5 mm slice thickness was employed for axial imaging, while 1.5 mm was utilized for tracking reconstruction. The ureteral tracking technique offers an extensive visualization of the urinary tract, facilitating in the detection of stones and obstructions. A reduced slice thickness improves image clarity and elucidates anatomical details. The application of a thin slice thickness ( $\leq 1.5$  mm) is essential for enhancing picture clarity, facilitating in the identification of small, and minimizing interpretative inaccuracies. Consequently, the use of ureteral tracking reconstruction with a thin slice thickness is highly recommended as a standard practice for urological CT scans in kidney stone cases.

**Keywords:** Urology CT Scan, Ureter Tracking, Slice Thickness, Kidney Stones.

## 1. Introduction

The abdomen is the largest cavity in the human body, oval in shape and extending from the diaphragm to the pelvis. The abdominal cavity mainly contains organs of the digestive tract, such as the stomach, small intestine, and large intestine. In addition, this cavity also contains accessory organs and organs of the urinary system. The liver is located in the upper right part of the abdominal cavity, just below the diaphragm, covering the stomach and the beginning of the small intestine. The pancreas is located behind the stomach, while the bladder is located below the liver. The kidneys and adrenal glands are located in the upper rear of the abdominal cavity. The ureters extend from the kidneys to the bladder through the abdominal cavity (Pearce, 2009).



The urinary system, also known as the urinary tract, is a system that filters the blood so that it is free of substances that are still used in the body. The organs of the urinary system consist of the kidneys, ureters, bladder, and urethra. The four functions of the urinary system are to regulate the chemical composition of the blood, eliminate many substances that are not needed in the body, regulate fluid and electrolyte balance and volume, and maintain the body's acid-base balance (Lampignano & Kendrick, 2024).

The kidneys are one of the vital organs of the urinary system that play an important role and function to excrete metabolic waste products in urine and produce erythropoietin, a hormone that stimulates the bone marrow to form red blood cells (Sherwood, 2020). Kidney disease can also be a cause of mortality risk (Angella & Sihombing, 2021). Kidney diseases that occur in humans include acute kidney failure (AKF), chronic kidney failure (CKF), kidney tumours, kidney infections (pyelonephritis), obstructive nephropathy, hypertensive nephropathy, kidney cysts, inflammation of the glomerulus (glomerulonephritis), and kidney stones (nephrolithiasis) (Vaidya & Aeddula, 2024).

Symptoms experienced by patients with kidney stones include intense back pain or colic pain, severe pain accompanied by fever, poisoning, nausea and vomiting, blood in the urine, and difficulty urinating (Hapipah et al., 2022). However, in some cases, no significant symptoms are found with small stone sizes. This is also related to an unhealthy lifestyle that contradicts the Qur'an, which explains the prohibition against eating and drinking excessively.

Allah SWT says in the Qur'an, Surah Al-A'raf, verse 31:

*"O children of Adam, wear your beautiful clothes in every mosque and eat and drink, but do not be excessive. Indeed, He does not like those who exceed limits."*

This verse explains that, as servants of Allah SWT, we are asked to be fair in all matters. In this verse, Allah SWT commands us to wear good clothing when worshipping, whether during prayer, tawaf, or other acts of worship. In the context of worship, we have provided food and drink, so eat and drink whatever you like from halal, good and nutritious food and drink, but do not be excessive in anything, whether in worship by adding to the manner or amount, or in eating and drinking. For indeed, Allah does not approve of, that is, He does not bestow His mercy and rewards upon those who are excessive in any matter.

In the field of medicine, various supporting examinations are required to help diagnose a disease, one of which is radiological examination. Radiological examination refers to an examination that can be performed using X-ray radiation, namely a CT scan.

A CT scan is a diagnostic radiological examination tool that uses a computer to reconstruct images obtained from a series of detector rows that receive X-ray beams and experience energy absorption (attenuation) from the objects/organs they pass through (Lampignano & Kendrick, 2018).

Kidney stones (nephrolithiasis) are a condition that occurs due to the formation of hard deposits in the kidneys originating from minerals and salts. These deposits can appear in the kidneys, ureters, bladder, and even the urethra. The formation of kidney stones can also be influenced by diet and other factors. Based on their type, kidney stones are classified into four categories: calcium, uric acid, struvite, and cystine stones. Small kidney stones can move to the ureter, bladder, or urethra, potentially causing irritation to the urinary tract (Ferraro et al., 2020). According to a 2015 report from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), it is estimated that around 5-10% of the adult population worldwide experiences kidney stones. The United States Renal Data System (USRDS) report shows that the prevalence rate of kidney disease in the United States in 2012 was 114,813. In the United States and Europe, approximately 0.1-0.4% of the population develops kidney

stones each year, with a male-to-female ratio of 3:1. Meanwhile, in Indonesia, common kidney diseases include kidney failure and kidney stones, with 1,499,400 cases of kidney stones, most of whom are aged 30-60 years, with 10% being women and 15% men (Indonesian Ministry of Health, 2018).

CT scans serve as the gold standard for accurate imaging and are the preferred choice for diagnosing abnormalities in the urinary tract (Widiastari et al., 2022), especially urolithiasis, as they have a sensitivity of up to 98% and a specificity of 96-98% (Umar et al., 2023)

Urological CT scans are superior to IVP examinations because they provide more informative, detailed, and comprehensive images, as well as an assessment of the degree of obstruction and renal parenchymal mass. Using X-rays that rotate around the patient's body, a urological CT scan can also display images in axial, sagittal, and coronal sections, including 3D reconstructions and the use of tracking reconstructions, which have high clinical value. In addition to detecting stones or tumours in the urinary tract, this examination is also used to assess the function of the kidneys, ureters, and urinary bladder, as well as for kidney transplant preparation and to identify congenital abnormalities (Jeniyanthi et al., 2024).

To obtain high-quality images that provide accurate and precise diagnoses, the components that influence image quality in CT scans are spatial resolution, contrast resolution, and noise. One important parameter in image quality is the selection of slice thickness. Slice thickness refers to the thickness of the slice or section of the object being examined. Its value can be selected between 0.5 mm and 10 mm according to clinical needs (Almuslimiati et al., 2019). A greater thickness will produce images with lower detail, while a smaller thickness will provide higher detail. Increasing the thickness can cause artefacts to appear, while a thickness that is too thin can cause noise in the image (Hutami et al., 2021).

Before undergoing a urological CT scan, there are several preparations that need to be made by the patient based on research conducted by Damayanti and Firdaus (2021). CT scans have specific preparations, such as eating soybean porridge the day before the examination, fasting for 6 to 8 hours before the examination, taking two dulcolax tablets, and undergoing the examination in a supine position with the legs first entering the gantry and a slice thickness of 5 mm. According to Yudha et al. (2020), fasting for 12 hours before the examination is also required for a CT scan, and the patient should be in the supine position with the head entering the gantry first and a slice thickness of 10 mm.

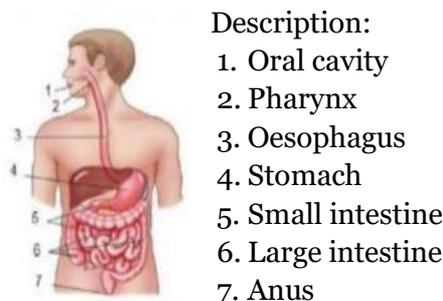
At the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital, no special preparations such as fasting are required for urological CT scan procedures. Patients are only instructed to drink 500-750 ml of mineral water for 20-30 minutes or until they feel the urge to urinate, and then to hold their urine before undergoing the urological CT scan. Additionally, patients are asked to remove any metal objects from their abdomen or wear a patient gown during the examination. The urological CT scan is performed using an abdominal examination protocol without contrast, with the upper limit below the diaphragm and the lower limit at the symphysis pubis. The slice thickness used is 5.00 mm for axial slices, 1.50 mm for tracking reconstruction and 3D imaging. The kV used is 120 kV.

This study aims to determine the clinical urological CT scan procedure for kidney stones, the reasons for performing kidney tracking reconstruction during image processing in clinical urological CT scans for kidney stones at the Radiology Department of Dr. Loekmono Hadi Kudus General Hospital, and to evaluate the optimal slice thickness for kidney tracking reconstruction to display optimal anatomical images and improve diagnostic accuracy.

## 2. Literature Review

### 2.1. Anatomy of the Abdomen

The abdomen is the part of the body located between the diaphragm at the top and the pubic symphysis at the bottom. Within the abdomen are two main systems: the digestive system and the urinary system. The digestive system includes the oral cavity, oesophagus, stomach, small intestine, large intestine, and anus. Meanwhile, the urinary system consists of the kidneys, ureters, bladder, and urethra (Lampignano & Kendrick, 2018).

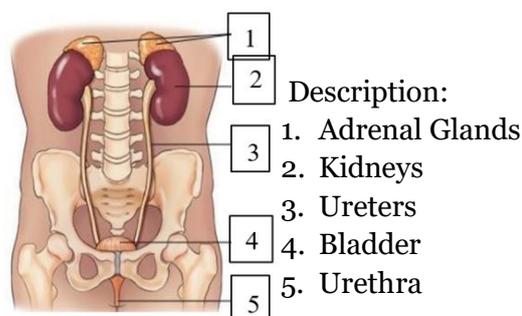


**Figure 1. Anatomy of the Abdomen**

Source: (Lampignano & Kendrick, 2018)

#### A. Anatomy of the Urinary System

The urinary system is a system in which blood is filtered so that it is free of substances that are not used by the body. Its functions include maintaining fluid and electrolyte balance, and excreting metabolic toxins such as nitrogenous components, particularly urea and creatinine (Hapipah et al., 2022). The organs of the urinary system include the kidneys, ureters, urinary bladder, and urethra. The anatomy of the urinary system can be seen in the diagram.

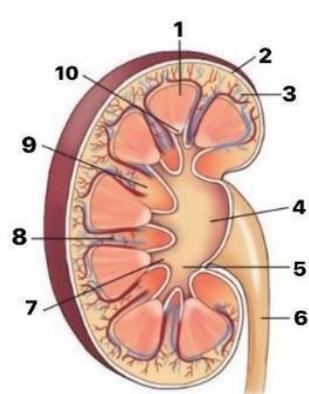


**Figure 2. Anatomy of the Urinary System**

Source: (Lampignano & Kendrick, 2018)

#### B. Anatomy of the Kidney

The kidneys are retroperitoneal organs, meaning they are located behind the peritoneum that lines the abdominal cavity. They are located between the twelfth thoracic and third lumbar vertebrae. The left kidney is usually located slightly higher than the right kidney due to the position of the liver (Black & Hawks, 2009). The kidney is composed of the cortex (renal cortex) and medulla (renal medulla). The medulla consists of several parts called renal pyramids (Pyramides renales). The kidneys function in the excretory process by filtering metabolic waste products from the blood, maintaining fluid and electrolyte homeostasis, and contributing to blood pressure regulation and various other physiological functions (Lampignano & Kendrick, 2018). The anatomy of the kidneys can be seen in the image.



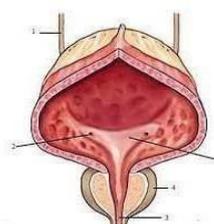
Description:

1. Medulla
2. Fibrous Capsule
3. Cortex
4. Renal Pelvis
5. Major Calyx
6. Ureter
7. Minor Calyx
8. Renal Sinuses
9. Renal Column
10. Renal Papilla

**Figure 3. Anatomy of the Kidney**  
Source: (Lampignano & Kendrick, 2018)

C. Anatomy of the Urinary Bladder

The urinary bladder, often referred to as the bladder or buli-buli, is a hollow organ in the pelvic cavity that functions to temporarily store urine before it is excreted through the urethra. Its location differs according to gender; in men, it is located between the pubic symphysis and the rectum, while in women it is located between the pubic symphysis and the uterus. The bladder has a conical shape surrounded by strong muscles, connected to the medium umbilical ligament (Hapipah et al., 2022). The anatomy of the urinary bladder can be seen in the image.



Description:

1. Right ureter
2. Ureter Opening
3. Urethra
4. Prostat gland
5. Trigone

**Figure 4. Vesica Urinaria Anatomy**  
Source: (Lampignano & Kendrick, 2018)

D. Anatomy of the Urethra

The urethra is the final channel of the urinary system that functions as a pathway for urine excretion from the bladder to outside the body. In males, the urethra is approximately 20 cm long and passes through several anatomical structures, starting from the bladder, crossing the middle of the prostate gland, penetrating the fibrous layer, and passing through the pubic bone to reach the penis. In contrast, in females, the urethra is shorter, approximately 3 to 4 cm, located posterior to the pubic symphysis, with a slight upward angle, and extends from the internal urethral orifice to the external urethral orifice through a relatively shallow canal (Hapipah, et al., 2022).

**2.2. Kidney Stone Pathology**

Kidney stones (nephrolithiasis) are a kidney disease in which stones are found, which are the most common cause of urinary tract disorders (Fauzi & Putra, 2016). Kidney stones are also a clinical condition that occurs due to the formation of crystal stones that block and interfere with kidney function, especially in the calyx or renal pelvis. This disorder is generally caused by an imbalance between the solubility and precipitation of salts in the urinary tract

and kidney tissue (Wahyuni et al., 2023). In general, nephrolithiasis occurs when minerals in the kidneys cannot be optimally excreted, causing them to precipitate and form sand-like particles. These stones have the potential to cause blockages in the ureter and bladder (Wahyuni et al., 2022).

### 2.3. Definition of Non-Contrast Urological CT Scan Examination

With today's sophisticated technology, kidney stones can be detected using a rapidly developing radiodiagnostic imaging modality, one of which is a CT scan. A CT scan is a diagnostic tool that uses a combination of X-rays and computers to obtain images or pictures in the form of cross-sections of the human body. One such examination is the urological CT scan, which is a specialised radiological examination without contrast used to detect diseases and evaluate the urinary system, starting from the kidneys, ureters, urinary bladder, and urethra (Lampignano & Kendrick, 2018).

### 2.4. Non-contrast Urological CT Scan Examination Procedure

The procedure for a urological CT scan is as follows: before the examination, the patient is asked to fast for 4–6 hours, then drink 1 glass of mineral water (220 ml) to help fill the urinary bladder and distend the ureter. After that, the patient is advised to drink 3 glasses of unsweetened tea (900 ml) to accelerate the diuresis process. Patients are also asked to remove all metal objects around the abdomen that could interfere with the quality of the radiographic image (Angella & Sihombing, 2021). The patient's position during the examination is supine with their feet first, both hands placed above their head, legs straight, and body aligned with the centre line of the examination table (MSP and MCP). Patients are provided with pillows, blankets, and body straps to prevent movement and are instructed to hold their breath during the examination scan (Damayanti & Firdaus, 2021).

### 2.5. Scanning techniques in non-contrast urological CT scans

Non-contrast CT scan urology examination scanning techniques are commonly used in cases of kidney stones (nephrolithiasis), as stones have high density and will appear clearly without the aid of contrast media. This CT scan urology examination is performed using an abdominal protocol from the upper border of the xiphoid process to the pubic symphysis. The scanning parameters are presented in the table below:

**Table 1. Scanning parameters in urological CT scans (Reiser et al., 2014)**

Tube Voltage (kV)	120 kV-130 kV
Tube Current (mA)	80 mA
Slice Thickness	3mm-5mm
Collimation Slice	0,6 mm
Table Feed	10
Gantry Rotation Time	0,3s
Pitch	0,9
Gantry Tilt	00
Image reconstruction	Tracking ureter

### 2.6. The Role of Ureter Tracking Techniques in Urological CT Scans

Non-contrast urological CT scans of the urinary tract also use tracking software that tracks the flow of the organ being assessed, thereby revealing the system consisting of the organs that produce urine and excrete it from the body, including the kidneys, ureters and urinary bladder (Mufida et al., 2023). The ureter tracking technique involves mapping the ureter pathway from the kidney to the urinary bladder using sagittal images, which are then

reformatted into a coronal view. This technique helps detect morphological abnormalities or obstructions in the urinary tract (Bontrager & Lampignano, 2014).

### 3. Methods

This research method uses a qualitative method with a case study approach. The qualitative method involves collecting data using research tools such as observation guidelines, interview guidelines, writing instruments, voice recorders and documentation. This research was conducted at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital from January to June 2025. Data analysis in this study began with data reduction, data presentation, discussion, and conclusions. The research ethics in this study were anonymity, confidentiality, justice, ensuring beneficence, non-maleficence, and ethical clearance (EC). This study has obtained research permission/ethical clearance (EC) with letter number: 43/KEPK/RSLH/V/2025.

## 4. Results and Discussion

### 4.1. Research Results

#### 4.1.1. Procedures for Urological CT scans at the Radiology Department of Dr Loekmono Hadi General Hospital, Kudus

The data results in this study were obtained by conducting observations of clinical urological CT scans of kidney stones and conducting direct interviews with radiographers, radiology specialists and referring doctors. The results of the interviews, observations and documentation are as follows:

##### Patient 1

Name : Mr. M  
 Age : 42 years old  
 Gender : Male  
 Medical Record Number : 9xxxxxxx  
 Photo Request : Urological CT Scan  
 Diagnosis : Nephrolithiasis

##### Patient 2

Name : Mr. K  
 Age : 54 years old  
 Gender : Male  
 Medical Record Number : 7xxxxxxx  
 Photo Request : Urological CT Scan  
 Diagnosis : Nephrolithiasis

##### Patient 3

Name : Mrs. S  
 Age : 48 Years Old  
 Gender : Female  
 Medical Record Number : 6xxxxxxx  
 Photo Request : Urological CT Scan  
 Diagnosis : Nephrolithiasis

On 15 May 2025, the three patients came to the urology clinic at Dr Loekmono Hadi Kudus Regional General Hospital complaining of pain in their lower back. The urologist then referred the patients for radiological examination, sending a request for a clinical CT scan of the kidneys to the Radiology Department. Based on this request, a CT scan of the kidneys was performed.

1) Patient Preparation

Urological CT scans for clinical kidney stones performed at Dr Loekmono Hadi Kudus Regional General Hospital on the three patients did not require any special preparation. Patients were only asked to drink 500-750 ml of water, depending on their ability, and to refrain from urinating during the examination. The details of the amount of water drunk by the three patients are as follows:

**Table 2. Amount of water consumed during urological CT scans**

Patient 1	600 ml
Patient 2	600 ml
Patient 3	750 ml

This is in line with the following statement from informant 4:

*“Patient preparation means drinking around 500-750 ml of water or a medium or large bottle of water, depending on the patient's ability. So, we also consider the patient's ability and then the patient holds their urine until the examination is performed. Later, when on the table, if the patient can still drink, they are given more to drink to see the ureter so that it is filled”* (I4/Radiographer)

2) Tools and Materials

Preparation of equipment and materials for urological CT scans in cases of kidney stones at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital, as follows: CT scan machine, operator console, film printer, feet holder, patient blanket, patient gown, patient pillow, body strap fixation device, and mineral water. This is in line with the statement of informant 4 after being interviewed about the preparation of equipment and materials:

*“The equipment and materials are, of course, a CT scan, which here is a Philips 128. Then there is film for printing, drinking water for patients to drink in preparation for filling their kidneys, ureters and urinary tract...”* (I4/Radiographer)

3) Urological CT Scan Examination Techniques

Based on observations and interviews regarding clinical urological CT scan techniques for kidney stones at the Radiology Department of Dr Loekmono Hadi Kudus Regional General Hospital, the procedure begins with the patient lying supine on the examination table with their feet first or close to the gantry and both arms raised above their head. The object position is set to the MSP (Mid Sagittal Plane) with the body aligned with the longitudinal light. The MCP (Mid Coronal Plane) of the patient is located at the midpoint of the horizontal light from the gantry, and the patient's arms are above their head. After the patient is positioned, a strap holder is attached to prevent the patient from falling off the examination table. During the examination, the patient is given a blanket for comfort, considering that the examination room is air-conditioned. The scanning parameters used for the three patients are as follows:

**Table 3. Scanning parameters used in urological CT scans**

Parameter Scanning	Patient 1	Patient 2	Patient 3
FOV	350 mm	500 mm	500 mm
Scan range	From the upper border of the diaphragm to the lower part of the pubic symphysis	From the upper border of the diaphragm to the lower part of the pubic symphysis	From the upper border of the diaphragm to the lower part of the pubic symphysis
kV	120	120	120
mAs	239	248	371
Gantry Tilt	0°	0°	0°
Slice Thickness	Axial cut 5.00 mm, and tracking 1.50 mm	Axial cut 5.00 mm, and tracking 1.50 mm	Axial cut 5.00 mm, and tracking 1.50 mm
Window Width	350 HU	255 HU	350 HU
Window Level	60 HU	60 HU	60 HU
Length	416,3 mm	331,1 mm	402,4 mm
Scan Time (s)	4.16 s	3.31 s	

4) Image Processing and Reconstruction

Based on the author's observations, clinical urological CT scans for kidney stones at Dr. Loekmono Hadi Kudus Regional General Hospital were performed with a pre-scanning slice thickness of 1.50 mm, an axial slice thickness reconstruction of 5.00 mm, a slice thickness of 1.50 mm for tracking reconstruction, and 3D reconstruction. Furthermore, the images were filmed and printed into two films, one film with a 6x5 layout consisting of one scannogram and 29 axial sections, and one film with a 3x3 layout consisting of rows 1 to 2 containing the tracking reconstruction results from the right kidney and left kidney positions, and row 3 containing the 3D reconstruction, namely images of one AP position, 1 Right Oblique, and 1 Left Oblique, presented in the three images below:

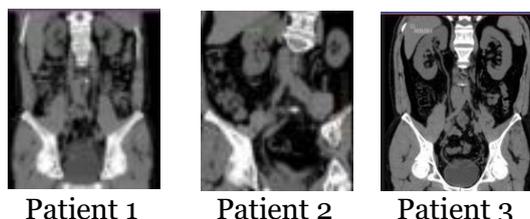
a. Axial section



**Figure 5. Axial CT scan images of the three patients during urological CT scans**

Source: (Radiology Department, Dr Loekmono Hadi General Hospital, Kudus, 2025)

b. Tracking Ureter



**Figure 6. CT scan images of the ureter from the three patients during urological CT scans**

Source: (Radiology Department, Dr Loekmono Hadi General Hospital, Kudus, 2025)

c. 3D reconstruction



Patient 1      Patient 2      Patient 3

**Figure 7. Results of 3D Reconstructed CT Scan Images of the three patients undergoing Urological CT Scan examinations**

Source: (Radiology Department, Dr Loekmono Hadi General Hospital, Kudus, 2025)

5) Radiologist's Findings

The radiographic findings from the clinical urological CT scan of kidney stones in the three patients were read by a radiologist as follows:

Patient 1:

*“Impression: Small nephrolithiasis in the midpole of the right kidney (size + 0.22 cm, CT number 177 HU, distance from the posterior cutis aspect + 8.34 cm), small nephrolithiasis in the lower pole of the left kidney (size + 0.15 cm, CT Number 96 HU, distance from the posterior cutis aspect + 8.73 cm), no blockage visible in either kidney or ureter, no stones visible in the urinary bladder.”*

Patient 2:

*“Simple impression on the right kidney, left nephrolithiasis -> stone in the middle pole {at the level of the corpus V. Th 12 – V.L1}, diameter approx. 0.32 cm, density approx. 98 HU (distance of lesion from posterior cutis approx. 5.8 cm), no stones visible in the right kidney and bilateral ureters, no abnormalities visible in the liver, VF, spleen, pancreas, VU or prostate, lumbar spondylosis.”*

Patient 3:

*“Impression: right kidney of normal size and shape, PCS not dilated, no stones visible; left kidney of normal size and shape, PCS not dilated, no stones visible; no stones or obstructions visible in either kidney or ureter; no stones visible in the urinary bladder.”*

**4.1.2. Reasons for Using Ureteral Tracking Reconstruction in Image Processing of Clinical Urological CT Scans of Kidney Stones**

Based on further observations and interviews conducted by the author, according to informants, the reason for using ureteral tracking reconstruction in image processing in urological CT scans for clinical kidney stones at Dr Loekmono Hadi Kudus Regional General Hospital is to display the anatomical details of the urinary tract from the kidneys to the ureters to the urinary bladder in a complete and comprehensive manner. ensure accuracy in establishing a diagnosis, facilitate clinicians in determining further patient treatment, determine the location of the stone which will influence the selection of further treatment, be useful for clinicians in both pre-operative and post-operative procedures, and be recommended by clinicians and approved by radiologists. This is in accordance with the statements of informants 1, 2, and 4:

*“So, the use of reconstruction tracking is to make it easier for clinicians. For example, I am a diagnostic doctor, a radiologist, for clinicians or surgeons or urologists, who are sometimes confused when reading axial sections. Tracking is used to make it easier for them to explain to patients or for them to perform post-operative or pre-operative procedures.”* (I1/Radiologist)

*“Oh yes, we usually use reconstruction to determine the location of the stone, which will affect the choice of treatment or surgery. It is very useful for what is called pre-operative surgery.” (I2/Referring Doctor)*

*“The reason for ureter tracking is that axial or coronal slices cannot show a complete picture of the kidney and so on up to the VU. However, with tracking, we can see the entire kidney, ureter, and VU in one slice without any interruptions. This makes the image easier to interpret and improves the diagnosis because the renal tract is visible in a single slice.” (I4/Radiographer)*

#### **4.1.3. The use of slice thickness in performing ureteral tracking reconstruction to produce optimal images and improve diagnostic accuracy in patients**

Based on observations conducted at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital, it was found that during CT scan image processing, the slice thickness used for axial, sagittal and coronal images was 5.00 mm. Meanwhile, the slice thickness used for ureter tracking reconstruction in image processing ranges from approximately 1.50 mm to 3.00 mm, but radiographers most commonly use a range of approximately 1.50 mm to 2.00 mm. This is in line with the statements of informants 3 and 4:

*“Usually, a range of 1.00 mm to 5.00 mm is used, but we more often use 5.00 mm.” (I3/Radiographer)*

*“For kidney tracking, the most common slice thickness is around 2–3, but mostly 2, though we also consider whether the stone is large or small. If the slice thickness is large, around 1.5–2mm, we might be able to see the surrounding stones, but for smaller stones, we may need to reduce the slice thickness.” (I4/Radiographer)*

## **4.2. Discussions**

### **4.2.1. Urological CT Scan Examination Procedure**

#### **A. Patient Preparation**

Based on the results of observations at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital, the three patients listed in the results table did not undergo any special preparation for the non-contrast urological CT scan examination technique. However, the three patients were instructed to drink only mineral water, approximately 500-750 ml, with the following details: patient 1 drank 600 ml, Patient 2 was instructed to drink 600 ml, and Patient 3 was instructed to drink 750 ml. This was based on the ability and body size of the patients to drink the amount of mineral water and hold their urine during the examination, which was aimed at filling the urinary bladder and optimally visualising the ureter. The three patients were also instructed to remove all metal objects from the area of the organ to be examined to avoid image artefacts in the radiographic results.

According to Quaia (2014) in their research, before undergoing a urological CT scan, patients are asked to fast for about 2–3 hours to improve the quality of the urinary tract images, prevent aspiration, and facilitate visualisation of the urological organs without interference from the contents of the gastrointestinal tract. Then, the patient drinks 750–1000 ml of mineral water for 10–20 minutes before the urological CT scan is performed. According to Angella et al. (2021), patient preparation for a urological CT scan involves fasting for approximately 4–6 hours, drinking one glass (220 ml) of mineral water, three glasses (900 ml) of strong tea, and refraining from urinating.

According to researchers, patient preparation for a urological CT scan at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital differs from that described by (Quaia, 2010). The journal article by Angella et al. (2021) explains that there are

instructions to fast for approximately 2–3 hours or 4–6 hours. patients are instructed to drink 750-1000 ml of water and refrain from urinating until the examination is complete, with the aim of ensuring the bladder is fully filled and the ureter can be optimally visualised.

## **B. Preparation of Tools and Materials**

Based on observations and interviews, the preparation of equipment and materials for urological CT scans for clinical kidney stones at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital includes a 128-slice CT scanner, blankets, mineral water, patient gowns, body strap fixation devices, film printers, and operator computers.

According to Seeram (2015), the equipment and materials used in urological CT scans are a CT scanner, automatic injector, intravenous contrast media, printer, operator computer, blanket, body strap fixation, and sterile equipment. According to Umar et al. (2023), urological CT scans require a CT scan machine, control console, printer, change of clothes, blanket, pillow, and 750 ml of unsweetened tea.

According to the researchers, there are differences in the preparation of equipment and materials for urological CT scans in the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital between Seeram (2015) and the journal by Umar et. al (2023), the preparation of equipment and materials for urological CT scans in cases of kidney stones at the Radiology Department of Dr. Loekmono Hadi General Hospital in Kudus only requires plain water, as urological CT scans do not require special preparation.

## **C. Inspection Techniques**

The technique for performing a urological CT scan for kidney stones at the Radiology Department of Dr Loekmono Hadi Kudus Regional General Hospital begins with the patient lying supine on the examination table with their feet first or close to the gantry and both arms raised above their head. The object position is set to MSP (Mid Sagittal Plane) with the body parallel to the longitudinal light. The MCP (Mid Coronal Plane) of the patient is located in the middle of the horizontal light from the gantry and the patient's arms are above the head. After the patient is positioned, a strap holder is attached to the patient to prevent them from falling off the examination table or moving. During the examination, the patient is given a blanket for comfort, considering that the examination room is air-conditioned. The scanning parameters used for the three patients are different, adjusted to the patient's body size, with the following details: FOV for patient 1 is 350.00 mm, patient 2 is 500.00 mm, and patient 3 is also 500.00 mm. The scan range was from below the diaphragm to just above the symphysis pubis, with exposure factors of 120 kV, 239 mA for patient 1, 120 kV, 248 mA for patient 2, and 120 kV, 371 mA for patient 3. Gantry tilt 0, pre-scanning slice thickness 1.50 mm, axial slice thickness reconstruction 5.00 mm, tracking slice thickness 1.50 mm, and 3D reconstruction.

According to Damayanti and Firdaus (2021), the patient lies supine on the examination table with their feet first and both arms placed above their head, both legs straight down, and the mid-sagittal plane (MSP) of the patient's body placed in the centre of the examination table. The patient is provided with a blanket and pillow for comfort, as well as a body strap to keep the patient stable and prevent movement, thereby avoiding the risk of falling. Position the patient so that the abdominal area is covered within the radiation field, adjust the position so that the MSP of the body is aligned with the longitudinal indicator light, the Mid Coronal Plane (MCP) is aligned with the horizontal indicator light, and then instruct the patient to take a full breath, exhale, and hold their breath. According to Yudha et al. (2020), the scanning parameters used in non-contrast urological CT scans are a tube voltage of 120 kV, a tube current of 240 mA, and a slice thickness of 10 mm. According to Umar et al. (2023), the scanning parameters for non-contrast urological CT scans use a tube voltage of 120 kV, tube

current of 40 mAs, and slice thickness of 3 mm. According to Haq et al. (2025), the scanning parameters for urological CT scans are a tube voltage of 120 kV, a tube current of 67 mAs, and a slice thickness of 5 mm.

According to the researcher, the urological CT scan examination technique used at the Radiology Department of Dr. Loekmono Hadi General Hospital in Kudus is similar to that described in Damayanti and Firdaus (2021). The urological CT scan examination technique at the Radiology Department of Dr. Loekmono Hadi General Hospital in Kudus uses a feet-first scanning position, where the feet enter the gantry first. However, there are differences in the parameters used at Dr. Loekmono Hadi General Hospital in Kudus, specifically in terms of tube current strength and slice thickness, as described in Yudha et al. (2020). The tube current strength used at Dr. Loekmono Hadi General Hospital in Kudus is an automatically adjusted parameter based on the patient's thickness. The slice thickness used is 5.00 for axial slices and 1.50 mm for tracking reconstruction. The slice thickness used is 5.00 for axial slices and 1.50 mm for tracking reconstruction, which are the most commonly used and are automatically set in the CT scan machine settings at Dr. Loekmono Hadi Kudus General Hospital.

#### **4.2.2. Reasons for Using Ureteral Reconstruction Tracking in Clinical Urological CT Scan Examinations of Kidney Stones**

Based on the results of observations of the reasons for using tracking reconstruction in urological CT scans with clinical kidney stones at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital, the use of tracking reconstruction is recommended by clinicians and has been approved by radiologists. Based on interviews with radiologists, tracking reconstruction can clearly display the anatomy of the urinary tract, including the kidneys, ureters, the urinary bladder, and the urethra (ureteropelvic junction, pelvic brim, ureterovesical (UV) junction, left ureter, left psoas major, left kidney, right kidney, right ureter, right psoas major). In addition, the use of kidney reconstruction tracking can determine the location, size, and number of kidney stones, detect obstructions in the urinary tract, and visualise the entire ureter pathway, thereby assisting both clinicians and radiologists in making an accurate diagnosis.

According to Frank et al. (1998), the use of tracking reconstruction techniques can map the shape and direction of the urinary tract in three dimensions, thereby facilitating the identification of the location, size, and density of stones, as well as the relationship of stones to the anatomical structures of the urinary tract. As noted by Damasio et al. (2013), clinically, tracking reconstruction is also important to avoid misinterpretation due to overlapping structures or artefacts that may appear in standard axial images. Therefore, this technique is recommended in modern urological CT scan protocols as it significantly contributes to diagnostic accuracy and efficiency in planning further actions. According to Tan et al. (2021), the use of tracking reconstruction is useful for improving preoperative planning and intraoperative navigation by providing better visualisation of kidney stones and surrounding structures, thereby reducing the risk of complications.

The researchers concluded that the use of tracking reconstruction in urological CT scans for kidney stones contributes significantly to improving diagnostic accuracy. The ability of this tracking technique to present a three-dimensional image of the urinary tract allows for a more comprehensive visualisation of the direction and anatomical configuration of the urinary tract. This visualisation is crucial in helping to identify the exact location of kidney stones, as well as in assessing their size and density with greater precision. This accuracy is vital in supporting the diagnostic process and in selecting appropriate medical interventions. In addition, tracking reconstruction can also minimise potential misinterpretations due to the limitations of axial section images, such as overlapping structures or the appearance of artefacts that can

interfere with the anatomical image. With these capabilities, the tracking technique not only supports diagnostic accuracy but also plays an important role in the efficiency of planning follow-up actions by both radiologists and clinicians.

#### **4.2.3. The use of Slice Thickness to reconstruct ureter tracking, thereby producing optimal images and improving the accuracy of patient diagnosis**

Based on observations conducted at the Radiology Department of Dr. Loekmono Hadi Kudus Regional General Hospital, it was found that during CT scan image processing, the slice thickness used for axial, sagittal and coronal images was 5.00 mm. Meanwhile, the slice thickness used for ureter tracking reconstruction in image processing ranges from approximately 1.50 mm to 3.00 mm, but radiographers most commonly use a range of approximately 1.50 mm to 2.00 mm to obtain optimal anatomical details of the urinary tract. This is in line with the research by Astari et al. (2024), which explains that in CT scans of the head with minor trauma, the use of a slice thickness of 5 mm can provide clear anatomical images, including detecting bleeding and fractures, as well as facilitating axial, bone, and 3D reconstruction. Thus, the selection of slice thickness in both head and urological examinations plays an important role in producing accurate and diagnostic images.

According to Umbach et al. (2019), the use of thin slice thickness ( $\leq 1.50$  mm) in urological CT scans is very important to improve image sharpness, especially in non-contrast imaging. This aids in identifying small kidney stones and in the process of 3D reconstruction and comprehensive tracking of the urinary tract. According to Yudha et al. (2020), the use of a slice thickness of 1–2 mm has been proven effective in visualising the ureter and the spatial relationship of kidney stones to the urinary system, particularly when performing multiplanar reconstruction (MPR) tracking and volume rendering (VR).

The researchers argue that the selection of a slice thickness of 1.50 mm in the ureter tracking reconstruction process is an appropriate step because it provides advantages in terms of image sharpness and anatomical structure clarity. This thin slice thickness allows for more detailed visualisation of kidney stones and improves accuracy in determining their location and size. Additionally, this technique strongly supports advanced reconstruction methods such as multiplanar reconstruction (MPR) and volume rendering technique (VRT), which ultimately improve diagnostic accuracy and treatment planning efficiency. Therefore, researchers recommend that the use of slice thickness  $\leq 1.50$  mm should remain the primary standard in urological CT scan protocols, especially when the primary objective is comprehensive visualisation of the anatomical details of the urinary tract.

## **5. Conclusion**

The procedure for clinical urological CT scans for kidney stones at the Radiology Department of Dr Loekmono Hadi Kudus Regional General Hospital begins with patient preparation, which involves removing any metal objects from the abdominal area. Patients are then instructed to drink plenty of water, depending on their ability or body size, until they feel the urge to urinate, at which point the CT scan is performed. The examination begins with the patient positioned supine (lying on their back) with their feet first entering the gantry and their hands placed above their head. The examination begins with the following scan parameters: scan area from below the diaphragm to the symphysis pubis, slice thickness of 5.00 for axial sections and 1.50 mm for ureter tracking reconstruction and 3D reconstruction. The slice thickness used is 5.00 for axial sections and 1.50 mm for tracking reconstruction, FOV 350-500 mm, scan time 0.76 s – 4.16 s, gantry tilt 00, 120-130 kV.

The reason for using ureteral tracking reconstruction in image processing in urological CT scans is to display the entire anatomy of the urinary tract, including the kidneys, ureters, urinary bladder, and urethra (ureteropelvic junction, pelvic brim, ureterovesical junction, left ureter, left psoas major, left kidney, right kidney, right ureter, right psoas major). Additionally, the use of renal tracking reconstruction can determine the location, size, and number of kidney stones, detect obstructions in the urinary tract, and visualise the entire ureter pathway, thereby facilitating clinicians in determining further patient management.

The selection of a slice thickness of 1.50 mm in the ureteral tracking reconstruction process is an appropriate step because it provides advantages in terms of image sharpness and anatomical structure clarity. This ureteral tracking technique minimises interpretation errors due to overlapping structures in conventional axial images, thereby improving diagnostic accuracy and clinical decision-making efficiency.

According to the researchers, the Radiology Department at Dr. Loekmono Hadi Kudus Regional General Hospital is advised to standardise the clinical urological CT scan procedure for kidney stones, particularly in the patient preparation stage, to ensure optimal and consistent image quality. Additionally, ureteral tracking reconstruction should be incorporated into routine protocols as it has been proven to display the entire urinary tract anatomy, facilitate the identification of stone location, size, and number, and support diagnostic accuracy and communication between radiologists and clinicians.

Furthermore, the use of thin slice thickness ( $\leq 1.50$  mm) in ureteral tracking reconstruction should also be established as a standard because it can improve image sharpness, clarify anatomical details, and minimise interpretation errors, especially in small stones. Through optimisation of procedures, implementation of tracking reconstruction, and appropriate selection of slice thickness, it is hoped that urological CT scans can provide accurate diagnostic images and support rapid and precise clinical decision-making.

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