

# Kidney Stone Treatment Using the Percutaneous Nephrolithotomy Method (PCNL)

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## ABSTRACT

Kidney stones are a serious condition that often occurs in the wider community. The presence of this disease is influenced by genetic factors, diet, dehydration, irregular lifestyle, and unhealthy lifestyle. One of the treatments used to treat kidney stones is Percutaneous Nephrolithotomy (PCNL) for kidney stones measuring more than two centimeters. This study aims to find out about kidney stone treatment using the PCNL method. The method used is a literature study by discussing five study focuses, namely (1) healthy kidney structure and its role in maintaining body balance, (2) kidney structural abnormalities and their impact on health, (3) kidney stone treatment methods and their impact on health, (4) PCNL as a modern treatment solution for kidney stone sufferers, and (5) the process of implementing PCNL in kidney stone treatment. It can be concluded that healthy kidneys are vital organs with integrated structures and functions to maintain the physiological balance of the body and play a role in producing the hormones renin, erythropoietin, and calcitriol. Kidney disorders that often appear are kidney stones caused by waste in the blood or crystallized chemicals such as calcium and oxalic acid. Pharmacological therapy is a therapy that is often used to treat kidney stones using medical drugs and also surgery, but this method has side effects due to the drugs given. PCNL is a non-invasive treatment that utilizes sophisticated medical technology to treat kidney stones. PCNL treatment is done by making a small incision in the skin of kidney stone sufferers so that it does not have significant side effects. PCNL has a high success rate for the treatment of kidney stones.

**Key words:** kidney stone; non-invasive; PCNL; renal

## INTRODUCTION

The kidneys are organs responsible for carrying out filtration in the body. They also play a crucial role in the body's metabolic processes. The condition of the kidneys is influenced by lifestyle and daily activities, such as whether they are regular or irregular (Alamsyah & Normalisa, 2019). When the kidneys are weakened, other

diseases can more easily attack the body (Maulana *et al.*, 2023). To maintain kidney health, it is important to ensure that the body has an adequate amount of fluids so the kidneys can function properly (Yusuf & Nasution, 2023).

Kidney stones are a type of disease that occurs in the urinary tract (Widiasti & Ernawati, 2021). They are crystals formed due to supersaturation of urine and disruption of kidney acidity. These stones are composed of substances such as magnesium, ammonium, uric acid, or combinations of these components (Djamhuri *et al.*, 2016). Kidney stones can develop in the kidneys, ureters, bladder, or urethra. This disease is commonly referred to as nephrolithiasis

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(Mahmudah & Nopiyanti, 2019). Kidney stones are caused by several factors, one of which is the accumulation of substances in the urine that form in the kidneys and urinary tract (Utami *et al.*, 2020). The formation of kidney stones occurs more rapidly when urine is highly concentrated and fluid intake is low. Kidney stones can affect people of various age groups, especially adolescents and adults.

In general, the formation of kidney stones is caused by intrinsic factors (originating from within the body) and extrinsic factors (originating from outside the body). Intrinsic factors include age, sex, and hereditary traits. Meanwhile, extrinsic factors involve geographical conditions, climate, dietary habits, and the presence of substances or chemicals in the water or other materials consumed by humans (Silalahi, 2020). In addition, lack of physical activity and insufficient water intake also increase the risk of kidney stone formation. The development of kidney stones is closely related to a person's habits and lifestyle (Harnianthy *et al.*, 2023). Therefore, it is very important to maintain a healthy lifestyle.

Currently, kidney stone disease is widespread globally and continues to increase annually. Over the past year, there has been a significant rise in kidney stone cases among individuals aged 15 to 20 years. In this age group, the risk of kidney stone

formation is very high, reaching up to 70% (Shastri *et al.*, 2023). This is due to the lack of awareness and concern among teenagers and young adults regarding their health (Suharmanto, 2023). Many of them consume food and beverages containing various substances and chemicals.

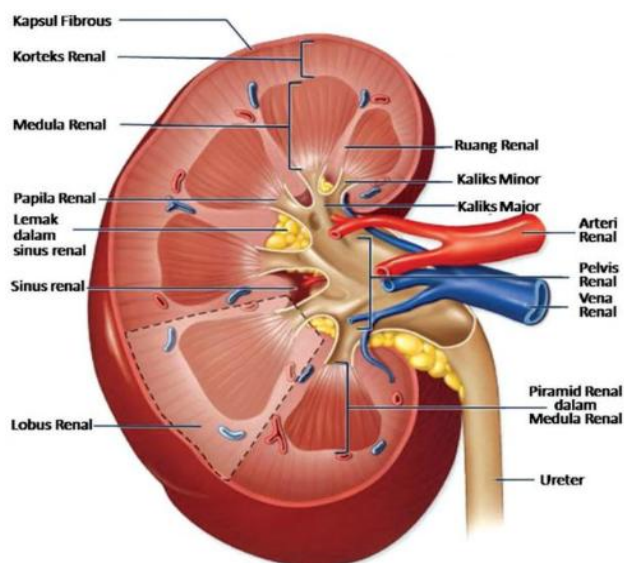
In treating this condition, various methods have been employed. One of the technologies used to treat large and complex kidney stones is Percutaneous Nephrolithotomy (PCNL). This procedure is typically used for kidney stones larger than 2 cm (Ilham *et al.*, 2024). It is a minimally invasive method that allows for the removal of kidney stones through a small incision in the back, using special instruments to break and extract the stones. PCNL has become an effective treatment option for kidney stone cases that are difficult to manage with other methods, delivering good and efficient outcomes for patients.

## MATERIALS AND METHODS

The method used in this research is a literature review. This approach was chosen as the primary method to collect and analyze information from various academic sources. It involves utilizing a range of scientific references, including research journals, textbooks, and study reports relevant to the topic under review—particularly those accredited by SINTA. The literature review method was employed due to the limitations in conducting direct research by the author. The data were collected and then categorized into the following groups: healthy kidney structure (12 journals), damaged kidney structure (8 journals), kidney stones (11 journals), and kidney stone treatment (5 journals). The collected data were analyzed using descriptive analysis to explain the characteristics of each research focus and the obtained information, allowing the discussion to provide a clear and structured overview.

## RESULTS AND DISCUSSION

### Healthy kidney structure and its role in maintaining body balance



**Figure 1.** Healthy kidneys (Tilong, 2015).

The human body is composed of various organ systems, one of which is the kidneys. The kidneys are a pair of bean-shaped organs located on either side of the spine, just below the rib cage (Bawazier, 2017). In adults, each kidney measures approximately 12–13 cm in length, 6 cm in width, 2.5 cm in thickness, and weighs around 150 grams. The kidneys are vital organs designed with a structure and function that work together to maintain the body's balance. A healthy kidney structure consists of several main components: the cortex, medulla, and renal pelvis. Within the cortex are nephrons, which are the functional units of the kidneys. Each healthy kidney contains about one million nephrons, composed of glomeruli and tubules. The glomerulus is responsible for filtering blood, while the tubules serve as channels for the reabsorption and secretion of essential substances. Ideally, kidney structure should include good blood vessels, strong connective tissue, and show no signs of inflammation or fibrosis (Julisawaty *et al.*, 2020).

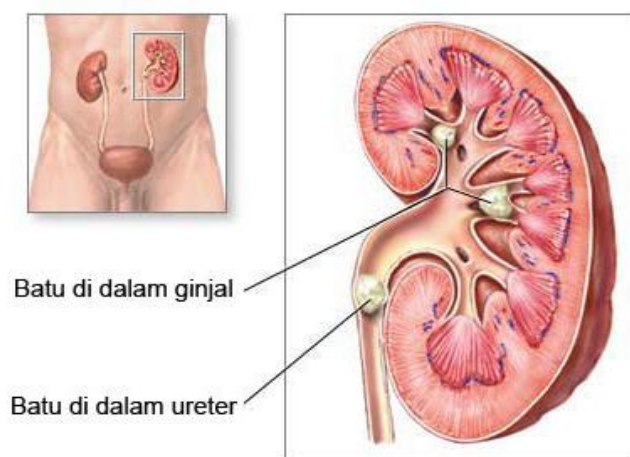
Healthy kidneys are vital organs with integrated structure and function that work together to maintain the body's physiological balance. A healthy kidney has a smooth surface without lesions, a symmetrical size, and no abnormalities such as cysts or tumors that could interfere with its normal function. Proper blood flow throughout the kidney is essential to ensure a consistent supply of oxygen and nutrients (Davey, 2005). Healthy kidneys serve as the primary regulators of fluid and electrolyte balance, blood pressure control, and the elimination of waste products through urine. Their main functions include filtering the blood to remove toxins and metabolic waste such as urea and creatinine, regulating the concentration of essential ions such as sodium, potassium, and calcium, and maintaining the body's acid-base balance.

Kidneys also produce essential hormones, including renin, erythropoietin, and calcitriol. Renin functions to regulate blood pressure through the renin-angiotensin-aldosterone system (RAAS). This system plays a key role in maintaining sodium balance, extracellular fluid volume, renal vascular resistance, and systemic

vascular resistance (Toreh *et al.*, 2013). Erythropoietin stimulates the bone marrow to produce red blood cells (Akhdiyat, 2020). Calcitriol is the active form of vitamin D and plays an important role in calcium and phosphate metabolism. It activates vitamin D receptors (VDR), which regulate genes involved in calcium metabolism, cell proliferation, differentiation, and immune function (Natasya, 2024). Optimal kidney function is crucial for maintaining homeostasis, regulating normal blood pressure, and eliminating metabolic waste and toxins from the body (Julisawaty *et al.*, 2020). The harmonious interaction of kidney structure and function makes the kidneys vital organs for sustaining overall health.

The kidneys consist of several parts. The outer part of the kidney is covered by a fibrous capsule, which serves to protect the kidney from trauma. Beneath the fibrous capsule lies the renal cortex, the outer layer of the kidney that contains the glomeruli and proximal tubules, where blood filtration occurs (Tilong, 2015). Below the cortex is the renal medulla, composed of pyramid-shaped structures known as renal pyramids (Verdiansah, 2016). The tips of these pyramids point toward the renal papillae, which function to drain urine into the minor calyces (Ham & Saraswati, 2020). Several minor calyces merge to form a major calyx, which then channels urine into the renal pelvis. The renal sinus is a cavity surrounding the pelvis that contains fatty tissue, blood vessels, and urine ducts (Kuntoadi, 2022).

The internal structure of the kidney includes renal lobes, which are formed by a renal pyramid and the surrounding cortex (Suryani *et al.*, 2024). The renal artery delivers oxygen- and nutrient-rich blood to the kidney for filtration (Kuntoadi, 2022). After filtration, the processed blood exits the kidney through the renal vein and returns to systemic circulation (Umar & Utama, 2021). The urine formed in the kidney flows through the collecting ducts into the ureter, which connects the kidney to the bladder. Urine is stored in the bladder until it is expelled from the body.



**Figure 2.** An unhealthy Kidney (Source: Alelign & Petros, 2018).



**Figure 3.** PNCL Medication (Source: dor-nier.com).

### Kidney structural abnormalities and their impact on health

The human body is composed of various organ systems, each with its own functions to support the body's performance. When one of these systems is damaged, it can disrupt the overall functioning of the body. The kidneys are responsible for excreting metabolic waste products such as urea, creatinine, and uric acid (Apsari, 2018). If these substances accumulate, they can damage the kidneys and even become toxic to the body. Damaged kidneys may experience structural and functional impairments. Structurally, kidney damage such as glomerular injury can lead to proteinuria, while tubular disorders can affect the reabsorption of water and

electrolytes, both of which can have serious health consequences (Baradero, 2009). Kidney stones originate from waste substances in the blood that crystallize and accumulate in the kidneys (Hadibrata & Suharmanto, 2022). Chemicals such as calcium and oxalate are among the main contributors to stone formation. This process not only causes severe pain but also leads to structural damage in the kidneys and impairs their function. Kidney stones form when the urine contains high concentrations of crystal-forming substances. When their levels exceed the urine's ability to dilute them, crystals begin to form and eventually become stones. Calcium stones, particularly calcium oxalate, are the most common type (Mayasari & Wijaya, 2020). Oxalate is produced by the liver and also obtained from foods such as certain vegetables and chocolate. Excessive intake of vitamin D supplements may also increase calcium levels in the urine. Dehydration is another major risk factor, as insufficient water intake makes urine more concentrated and increases the risk of stone formation. Symptoms of kidney stones vary depending on the size and location of the stone. Patients often experience intense pain in the lower back or sides, which may radiate to the lower abdomen or groin (Sufiana *et al.*, 2022). This pain may be dull or severe and sharp, especially when the stone moves or blocks the urinary tract. Other common symptoms include nausea and vomiting caused by gastrointestinal irritation due to pain, as well as difficulty urinating accompanied by pain or a burning sensation.

Urine may appear bloody, cloudy, or have an unusual odor, which can indicate the presence of infection or irritation in the urinary tract. When such symptoms occur, it is crucial to seek medical attention promptly. Early diagnosis and appropriate treatment can help prevent serious complications, such as kidney infections or permanent kidney damage, which may have broader impacts on overall health.

The issue of kidney stones among individuals aged 15 to 22 has become increasingly urgent due to the rising prevalence in this age group and the potential long-term consequences for kidney health.

In adolescence and early adulthood, modern lifestyle habits—such as high-salt diets, frequent consumption of sugary drinks, and inadequate water intake—can trigger the formation of kidney stones (Kamaluddin & Rahayu, 2009). Irregular physical activity and academic stress further exacerbate the risk. Kidney stones that develop at a young age may lead to earlier and more progressive kidney damage.

Batu ginjal yang muncul pada usia muda memiliki potensi untuk menyebabkan kerusakan ginjal yang lebih dini dan progresif. Ketika batu ginjal terbentuk, mereka dapat menghalangi aliran urine dari ginjal ke kandung kemih, menyebabkan penumpukan urine dan meningkatkan tekanan di dalam ginjal. Hal ini dapat mengakibatkan hidronefrosis, yaitu pembengkakan ginjal akibat penumpukan urine, yang jika tidak ditangani dengan cepat dapat menyebabkan kerusakan permanen pada jaringan ginjal. Menurut data dari Kementerian Kesehatan, prevalensi penyakit ginjal kronis pada kelompok usia 15-24 tahun telah mencapai 1,33%, dengan angka ini terus meningkat seiring dengan perubahan gaya hidup dan pola makan (Kemenkes, 2023).

### **Kidney stone treatment methods and their impact on health**

Kidney stone treatment varies depending on the size and location of the stone. There are two general approaches to managing kidney stones: non-pharmacological therapy and pharmacological therapy. Non-pharmacological therapy refers to natural treatments that do not involve the use of medications. One form of natural and traditional therapy involves the use of herbal remedies (Ariana, 2022). This type of therapy can also be applied by adopting a healthy lifestyle, such as avoiding instant foods, foods high in fat, alcohol, and engaging in regular physical exercise (Pachaly *et al.*, 2016). This option is generally chosen for kidney stones that are small, do not cause urinary tract obstruction, and can be spontaneously passed through urine (Wahyuning, 2018).

However, non-pharmacological treatments can sometimes cause discomfort for some patients.

They often struggle to maintain adequate fluid intake, which increases the risk of dehydration (March *et al.*, 2022). This situation can occur in patients who are required to limit fluid consumption due to certain health conditions, such as heart failure or chronic kidney failure (Prihatiningsih & Sudyasih, 2018).

The effectiveness of this therapy is also limited for larger stones that can obstruct urine flow. Physical exercise, which is initially intended to help expel the stones, may in fact worsen the pain experienced by the patient. Therefore, non-pharmacological methods such as increasing fluid intake cannot always guarantee the complete elimination of kidney stones (Ibrahim, 2023).

Pharmacological therapy refers to treatment involving the use of medications and surgical procedures. This process is used to manage diseases that may have side effects resulting from the drugs administered (Ariana, 2022). Several commonly used pharmacological treatments for kidney stones include medical therapy, ESWL, and ureteroscopy. Medical therapy is typically applied for small-sized kidney stones, with recommendations such as increasing fluid intake, using pain relievers, and alpha-blockers to relax the muscles of the urinary tract so that the stones can pass naturally (Verdini *et al.*, 2016). Extracorporeal Shock Wave Lithotripsy (ESWL) is a non-invasive procedure that uses shock waves to break kidney stones into smaller fragments so they can be passed through urine, and is effective for medium-sized stones. Ureteroscopy (URS), on the other hand, involves the use of a ureteroscope inserted through the urinary tract to directly view and remove stones; if necessary, the stones can be broken down using a laser (Khusnia & Fachrurrazi, 2024).

The non-invasive ESWL procedure, which uses shock waves to break kidney stones, carries certain risks. Shock waves have the potential to damage surrounding kidney tissues and may cause renal hematoma, which is bleeding within the kidney (Anas *et al.*, 2016). Patients may also experience pain following the procedure. This pain can occur as stone fragments pass through the urinary tract, and it can be more intense if



there is a blockage in the urinary tract (Wulandari, 2022). The effectiveness of ESWL is limited to small-sized kidney stones; if the stone is larger than 20 mm and composed largely of calcium oxalate monohydrate, it becomes more difficult to fragment (Bilqisthi *et al.*, 2023).

### PCNL as a modern treatment solution for kidney stone patients

Percutaneous Nephrolithotomy (PCNL) is a minimally invasive surgical procedure specifically designed to treat large kidney stones or those located in areas that are difficult to reach using conventional methods (Hadibrata *et al.*, 2023). PCNL was first introduced in 1976 and remains one of the gold standard procedures for kidney stone treatment to this day (Hardjowijoto *et al.*, 2015).

Kidney stones form when minerals and salts in the urine crystallize and develop into hard masses within the kidneys. These stones can vary in size, from small to large. While large kidney stones are difficult to break using ESWL, PCNL offers a more effective alternative. Stones measuring over 20 mm can be managed using this treatment method. Percutaneous nephrolithotomy is a minimally invasive surgical procedure specifically designed to treat large kidney stones or those located in hard-to-reach areas using conventional methods (Hadibrata *et al.*, 2023). First introduced in 1976, PCNL remains a gold standard treatment for kidney stones (Hardjowijoto *et al.*, 2015).

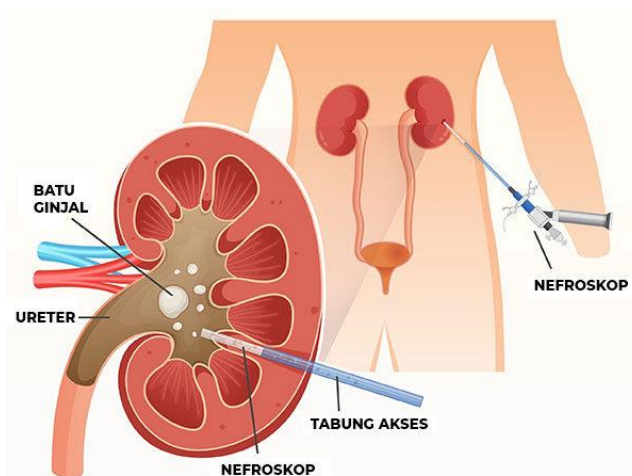
This procedure begins with a small incision made in the lower back, allowing doctors to insert specialized instruments directly into the kidney through the skin. With the help of these instruments, kidney stones are fragmented into smaller pieces and then removed from the body. One of the major advantages of PCNL is its ability to treat larger and more complex stones, making it a preferred option when non-invasive methods are ineffective (Murti & Rasyid, 2008). Furthermore, since it only requires a small incision, PCNL carries a lower risk of complications compared to traditional open surgery. Patients typically experience shorter recovery times and less

postoperative pain. The procedure also allows for more thorough stone removal, which helps to reduce the likelihood of recurrence.

PCNL is generally recommended for patients with large kidney stones, those who do not respond to non-invasive methods, or patients who fail to recover with conservative treatment (Rosette *et al.*, 2011). Potential complications of the treatment include infection or injury to the kidneys or surrounding organs. Therefore, proper patient selection is essential to ensure the procedure's success. Additionally, the skill of the medical team and the availability of proper medical equipment are crucial factors that enhance the success rate. Despite these considerations, PCNL remains a primary treatment option for managing complex kidney stone cases (Ali *et al.*, 2023).

### The application process of PCNL in kidney stone treatment

PCNL treatment involves a minimally invasive procedure designed to address large kidney stones or those causing complications. To measure the size and location of the kidney stones, diagnostic tools such as CT scans or ultrasonography are typically used (Noegroho & Daryanto, 2018). The patient is given general anesthesia to ensure comfort during the procedure. PCNL is performed under general anesthesia with



**Figure 4.** PCNL procedural illustration (Source: royalprogress.com).

the patient lying in a prone position. This positioning helps ensure patient comfort throughout the process. A small incision is then made in the back to insert an instrument called a nephroscope into the kidney through a tract known as the percutaneous access (Hadiwijono & Ratumasa, 2023). With the help of this instrument, the kidney stone is visualized and broken down using laser energy or other specialized tools. The stone fragments are then removed from the kidney. This process is effective in removing stones that cannot be treated with non-invasive methods and generally offers a shorter recovery time compared to open surgery. Once the procedure is complete, the patient is transferred to a recovery room for monitoring to assess progress during the healing phase.

The success rate of PCNL treatment is considered high. A study conducted by Bimanggo and Nur on kidney stone patients at Cipto Mangunkusumo Hospital showed a satisfactory result of 74.2%, indicating that almost all kidney stones could be managed using the PCNL method (Hernowo & Rasyid, 2017). Other studies and opinions from US urologists also confirm that PCNL meets high-quality standards, with success rates ranging from 83% to 95%, as demonstrated in research conducted at Abdul Moeloek Regional General Hospital (Hadibrata *et al.*, 2023). These findings indicate that PCNL is highly recommended for the treatment of kidney stones, particularly in cases involving large and complex stones. Further research also suggests that PCNL effectively improves patients' quality of life by enabling faster recovery, reducing pain symptoms, and minimizing complications. An intensive postoperative care approach can yield highly satisfying outcomes (Ariana, 2022).

## CONCLUSION

Kidney stone disease is one of the commonly encountered health problems, particularly among individuals aged 15 to 22. Kidney stones can form when the concentration of crystal-forming substances in the urine exceeds the body's ability

to dissolve them, leading to the formation of stones, especially calcium-based stones. These stones may develop due to high levels of calcium and oxalate in the urine, which are influenced by dietary factors, vitamin D supplementation, and certain body conditions. Dehydration is also a major risk factor, as low fluid intake results in more concentrated urine, increasing the likelihood of crystal formation. One of the technologies used for treating kidney stones is PCNL. PCNL, or Percutaneous Nephrolithotomy, is a minimally invasive surgical procedure effective in treating large or hard-to-reach kidney stones that cannot be managed using other methods. This procedure involves making a small incision in the lower back to insert instruments capable of breaking the stones and removing them from the body. The advantages of PCNL include lower complication risks, faster recovery times, and more complete stone removal, which helps reduce the chances of recurrence. Nevertheless, proper patient selection, skilled medical personnel, and adequate facilities remain key factors in ensuring the success of this procedure.

## REFERENCES

- Akhdiyat, H.R. 2020. Analisis kadar hemoglobin pada pasien penderita gagal ginjal kronik. *International Journal of Applied Chemistry Research*. 1(1): 1. DOI: 10.23887/ijacr.v1i1.28708.
- Alamsyah, A.P., and Normalisa. 2019. Sistem pakar diagnosa penyakit ginjal. *International Journal of Artificial Intelligence*. 6(1): 53-74.
- Alelign, T., and B. Petros. 2018. Kidney stone disease: An update on current concepts. *Advances in Urology*. 2018(1): 3068365. DOI: 10.1155/2018/3068365.
- Ali, M.W., Y.A. Azmi, Tarmono, and D.M. Soebadi. 2023. Percutaneous nephrolithotomy (PCNL) in older and younger patients at a tertiary hospital in Surabaya, Indonesia. *Folia Medica Indonesiana*. 59(1): 26-31. DOI: 10.20473/fmi.v59i1.40968.
- Anas, Y., A. Imron, and S.I. Ningtyas. 2016. Ekstrak daun kelor (*Moringa oleifera* Lam.) sebagai peluruh kalsium batu ginjal secara in vitro yance. *Jurnal Ilmu Farmasi & Farmasi Klinik*. 13(2): 7-15.
- Apsari, K. 2018. Struktur dan anatomi ginjal. *Poltekkes Kemenkes Denpasar*, 15.
- Ariana, R. 2022. Asuhan keperawatan pada Tn. M dengan post op percutaneous nephrolithotomy.

- Avriani, S., M. Jannah, and L.L. Sari. 2024. *Pelaksanaan kegiatan pembuatan oralit untuk pencegahan dehidrasi pada kasus diare di Batu Urip Lubuklinggau Utara II*. 3(2): 165-168.
- Baradero, M. 2009. Klien gangguan ginjal. Perpustakaan Nasional. Jakarta.
- Bawazier, L.A. 2017. *Pemeriksaan struktur dan fungsi ginjal*. 1-51. Fakultas Kedokteran Universitas Indonesia. Jakarta.
- Bilqisthi, A.R., B. Prasetyo, and R. Romadhoni. 2023. Korelasi ukuran batu ginjal dengan jumlah dilakukan ESWL di Rumah Sakit Islam Sultan Agung pada Tahun 2019. *Jurnal Surya Medika*. 9(2): 120-125. <https://doi.org/10.33084/jsm.v9i2.3618>.
- Dewi, Sufiana Puspita and Diyah Candra Anita. 2015. Hubungan lamanya hemodialisa dengan kualitas hidup pasien gagal ginjal di RS PKU Muhammadiyah Yogyakarta. *Jurnal Ilmiah Kesehatan*. Suharmanto
- Djamhuri, T.R., Yuliet, and K. Khaerati. 2016. Aktivitas penghambatan pembentukan batu ginjal (antinefrolithiasis) ekstrak etanol daun gedi merah (*Abelmoschus moschatus* Medik) pada tikus putih jantan. *Galenika, Journal of Pharmacy*. 2(1): 31-37.
- Hadibrata, E., and Suharmanto. 2022. Faktor-faktor yang berhubungan dengan terjadinya batu. *Jurnal Penelitian Perawat Profesional*. 4(3): 1041-1046.
- Hadibrata, E., M.D. Tjahyo, and Suharmanto. 2023. Efikasi dan komplikasi supine percutaneous nephrolithotomy (PCNL) dengan panduan kombinasi ultrasonografi (USG) dan fluoroskopi. *Jurnal Penelitian Perawat Profesional*. 5(1): 241-252.
- Hadiwijono, V.J., and M.C.R. Ratumasa. 2023. Quadratus lumborum block (QLB) pada percutaneous nephrolithotomy (PCNL): Tinjauan sistematis dan meta-analisis. *Majalah Anestesia & Critical Care*. 41(3): 211-217. Doi: 10.55497/majanestricar.v41i3.320.
- Ham, M.F., and M. Saraswati. 2020. Buku ajar patologi. Robbins 10<sup>th</sup> Indonesian edition. Singapore: Elsevier.
- Hardjowijoto S., Santoso A., Alif S., Soetojo, Tarmono, Djatisoesanto W., Hakim L., Soebadi A. M., Renaldo J., and Rizaldi F. 2015. Nefrolitotomi perkutan PCNL (percutaneous nephrolithotomy). Doddy M. Soebadi (Ed.). Departemen Urologi, Fakultas Kedokteran Universitas Airlangga - RSUD Dr. Soetomo Surabaya. ISBN 978-602-72485-1-9.
- Harnianthy, P.N.I., Nurmeini, and Y.F. Tipawael. 2023. Hubungan antar intake cairan dengan batu ginjal masyarakat. *Arisha, Jurnal Kesehatan Indonesia*. 1(1): 20-24.
- Hernowo, B., and N. Rasyid. 2017. Angka keberhasilan dan komplikasi PCNL pada pasien batu ginjal di Rumah Sakit Cipto Mangunkusumo Tahun 1999-2006. 15(1): 21-24.
- Ibrahim, M.N.M. 2023. Definisi nefrolithiasis. 7. <https://eprints.umm.ac.id/id/eprint/132/>.
- Ilham, M., Satyagraha, P., & Kustono, A. (2024). a Novel Technique Single Site Multipunctures Supine Pcnl: Case Series Report. *Indonesian Journal of Urology*, 31(1), 55-60. <https://doi.org/10.32421/juri.v31i1.925>
- Julisawaty, E.A., Hurnaningsih, and M.H. Ekasari. 2020. Aplikasi augmented reality tentang fungsi organ ginjal manusia dan cara menjaga kesehatannya. Seminar Nasional Teknologi Informasi dan Komunikasi STI&K, 4(1), 159-166.
- Kamaluddin, R., and E. Rahayu. 2009. Analisis faktor-faktor yang mempengaruhi kepatuhan asupan cairan pada pasien gagal ginjal kronik dengan hemodialisis di RSUD Prof. Dr Margono Soekarjo Purwokerto. *Jurnal Keperawatan Soediman*. 4(1): 20-31.
- Kemenkes. 2023. *Tren penyakit ginjal kronik bergeser ke usia produktif*. Jakarta.
- Khusnia, L., and Fachrurrazi. 2024. Anestesi spinal pada pasien hidronefrosis dextra et causa ureterolithiasis dextra. *Jurnal Ilmu Kesehatan Umum*. 2(2): 133-139.
- Kuntoadi, G.B. 2022. Buku ajar anatomi fisiologi 2. Penerbit Panca Terra Firma Publishing. Bandung.
- Mahmudah, K., and V. Nopiyanti. 2019. Penetapan kadar asam lemak bebas (Alb) pada minyak goreng kemasan dan minyak goreng curah dengan perlakuan berdasarkan lama waktu pemanasan. *CERATA Jurnal Ilmu Farmasi*. 10(1): 1-4. <https://doi.org/10.61902/cerata.v10i1.67>.
- Mansjoer, A., Soprohaita, W.I. Wardani, and W. Setiowulan. 2000. Kapita selekta kdokteran. Jilid 2. Media Aesculapius. Jakarta.
- March, D.S., T.J. Wilkinson, T. Burnell, R.E. Billany, K. Jackson, L.A. Baker, A. Thomas, K.A. Robinson, E.L. Watson, M.P.M. Graham-Brown, A.W. Jones, and J.O. Burton. 2022. The effect of non-pharmacological and pharmacological interventions on measures associated with *Sarcopenia* in end-stage kidney disease: A systematic review and meta-analysis. *Nutrients*. 14(9): 1-41. <https://doi.org/10.3390/nu14091817>.
- Maulana, M.A., A. Jamaludin, A. Solehudin, and A. Voutama. 2023. Sistem pakar diagnosis penyakit ginjal menggunakan metode certainty factor berbasis website. *Infotech Journal*. 9(2): 431-441.
- Mayasari, D., and C. Wijaya. 2020. Faktor paparan sinar matahari dan hiperkalsiuria sebagai faktor resiko pembentukan batu ginjal pada pekerja agrikultur. *Agromedicine Unila*. 7(1): 13-18.
- Murti, B.H., and N. Rasyid. 2008. Angka keberhasilan dan komplikasi PCNL pada pasien batu ginjal di Rumah Sakit Cipto Mangunkusumo tahun 1999-2006. *Indonesian Journal of Urology*. 15(1): 21-24.
- Natasya, N. 2024. Calcitriol (Vitamin D) sebagai anti-inflamasi. *Copyright Nurul Natasya INNOVATIVE: Journal of Social Science Research*. 4(4): 192-201.
- Noegroho, B.S., and Daryanto. 2018. Panduan penatalaksanaan klinis batu saluran kemih. In: *Ikatan Ahli Urologi ndonesia (IAUI)*. Jakarta.
- Pachaly, M.A., C.P. Baena, A.C. Buier, F.S. de Fraga, and M. Carvalho. 2016. Effects of non-pharmacological interventions on urinary citrate levels: A systematic review and meta-analysis. *Nephrology Dialysis Transplantation*. 31(8): 1203-1211. Doi: 10.1093/ndt/gfv303.
- Prihatiningsih, D., and T. Sudyasih. 2018. Perawatan diri pada



- pasien gagal jantung. *Jurnal Pendidikan Keperawatan Indonesia*. 4(2): 140-151. Doi: 10.17509/jpki.v4i2.13443.
- Rosette, J.D.L., D. Assimos, M. Desai, J. Gutierrez, J. Lingeman, R. Scarpa, and A. Tefekli. 2011. The clinical research office of the endourological society percutaneous nephrolithotomy global study: Indications, complications, and outcomes in 5803 patients. *Journal of Endourology*. 25(1): 11-17. Doi: 10.1089/end.2010.0424.
- Shastri, S., J. Patel, K.K. Sambandam, and E.D. Lederer. 2023. Kidney stone pathophysiology, evaluation and management: Core curriculum 2023. *AJKD*. 82(5): 617-634.
- Silalahi, M.K. 2020. Faktor-faktor yang berhubungan dengan kejadian penyakit batu saluran kemih pada di Poli Urologi RSAU dr. Esnawan Antariksa. *Jurnal Ilmiah Kesehatan*. 12(2): 205-212.
- Suharmanto. 2023. Perilaku kesehatan pasien batu ginjal. *Jurnal Penelitian Perawat Profesional*, 5(2): 811-818.
- Suryani, L., R.T. Purnomo, N. Hidayah. 2024. Buku ajar ilmu biomedik dasar. Penerbit Sonpedia Publishing Indonesia. Jambi.
- Tilong, A. 2015. Jam piket organ tubuh. FlashBooks. Yogyakarta.
- Toreh, R.M., S.J.R. Kalangi, and S. Wangko. 2013. Peran kompleks Jukstaglomerulus terhadap resistensi pembuluh darah. *Jurnal Biomedik*. 4(3): 42-51. Doi: 10.35790/jbm.4.3.2012.1213.
- Umar, M.S., and J.P. Utama. 2021. Anatomi tubuh manusia. Penerbit Samudra Biru. Yogyakarta.
- Utami, W.B., S. Suwarni, M.S. Amin, I. Kusumawardhani, N.S. Febriana, S.P. Arindra, and I.Z.S. Guinevera. 2020. Penyuluhan 2G (Cegah Batu Ginjal dan Sayangi Ginjal Dengan Pola Hidup Sehat) masyarakat RW VI Kelurahan Semanggi Kecamatan Pasar Kliwon. Prosiding Seminar Nasional Unimus.
- Verdiansah. V. 2016. Pemeriksaan fungsi ginjal. *CDK*. 43(2): 148-154.
- Verdini, V., N. Rasyid, and P. Birowo. 2016. Efficacy quotient tindakan ESWL piezolith richard wolf 3000 pada penderita batu ureter di RSUPN Dr. Cipto Mangunkusumo, 2008-2011. *Efficacy Quotient Tindakan ESWL*. 4(3): 191-196.
- Wahyuning, S. 2018. Panduan penatalaksanaan klinis batu saluran kemih. Edisi Pertama. In: Analisis Standar Pelayanan Minimal Pada Instalasi Rawat Jalan di RSUD Kota Semarang.
- Widiasti, Y., and I. Ernawati. 2021. Klasifikasi penyakit batu ginjal menggunakan algoritma decision tree C4.5 dengan membandingkan hasil uji akurasi. *Jurnal I IKRA-ITH INFORMATIKA*. 5(2): 128-135.
- Wulandari, A. 2022. Asuhan keperawatan pada Ny. S dengan post percutaneous nephrolithotomy batu ginjal di Ruang Baitul Izzah 1 RSI Sultan Agung Semarang. [Doctoral dissertation]. Universitas Islam Sultan Agung, Semarang.
- Yusuf, S.F., and L.K. Nasution. 2023. Penyuluhan tentang hidup sehat dengan menjaga fungsi ginjal di Kelurahan Bintuju Kecamatan Angkola Muaratais Tahun 2023. *Jurnal Pengabdian Masyarakat Darmas (JPMD)*. 2(1): 32-35.

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