RESEARCH ARTICLE

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Bacterial and Antibiotic Sensitivity Patterns in Patient Urine after Percutaneous Nephrostomy

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Abstract

Percutaneous nephrostomy (PN) is a urine diversion procedure using a tube, stent, or catheter. Knowledge of bacterial sensitivity to antibiotics can guide the establishment of an appropriate and safe treatment to reduce the incidence of percutaneous nephrostomy-related infection (PNCI). The purpose of this study was to determine the suitability of antibiotics medication based on the results of bacterial culture and bacterial sensitivity test. This study was a retrospective descriptive observational study on medical records of patient diagnosed with obstructive uropathy who underwent PN in the period January 2017 to December 2019. A total of 20 bacterial isolates were classified as gram-positive bacteria isolates (16.5%) and 101 isolates presented gram-negative bacteria (83.5%). The most frequent gram-negative bacteria identified in these isolates were *E. coli* (n=42), *Pseudomonas aeruginosa* (n=22), and *Klebsiella pneumonia* (n=20). Meanwhile, Staphylococcus aureus was seen in ten isolates with gram-positive bacteria. Vancomycin antibiotics had the best sensitivity to gram-positive bacteria based on the antibiotic sensitivity tests. On the other hand, meropenem and amikacin had the best sensitivity to gram-negative bacteria (83.2%). This study showed that the most common bacteria identified from nephrostomy patients is *E. coli* with meropenem and amikacin as the most sensitive antibiotic for these patients. Thus, antibiotic therapy before and after PN procedure should be considered wisely to prevent resistant PNCI.

Keywords: Antibiotic, bacterial, percutaneous nephrostomy, sensitivity

Pola Sensitivitas Bakteri dan Antibiotik pada Urin Pasien Setelah Nefrostomi Perkutan

Abstrak

Nefrostomi Perkutan (PN) adalah prosedur pengalihan urin menggunakan selang, stent, atau kateter. Mengetahui sensitivitas bakteri terhadap antibiotik dapat memandu untuk menetapkan pengobatan yang tepat dan aman untuk mengurangi kejadian infeksi terkait nefrostomi perkutan (PNCI). Penelitian ini bertujuan menentukan kesesuaian pengobatan antibiotik berdasar atas hasil kultur dan sensitivitas bakteri. Jenis penelitian observasional deskriptif. Penelitian ini meninjau secara retrospektif rekam medis pasien yang didiagnosis uropati obstruktif yang menjalani PN pada periode Januari 2017 hingga Desember 2019. Sebanyak 20 isolat bakteri tergolong bakteri gram positif (16,5%) dan 101 isolat bakteri gram negatif (83,5%). Isolat bakteri terbanyak adalah *E. coli* dengan 42 isolat, 22 isolat *Pseudomonas aeruginosa,* dan 20 isolat *Klebsiella pneumoniae* untuk bakteri gram negatif. Sepuluh isolat bakteri gram positif adalah *Staphylococcus aureus*. Antibiotik vankomisin memiliki sensitivitas terbaik terhadap bakteri gram positif berdasar atas uji sensitivitas antibiotik. Sedangkan antibiotik meropenem dan amikasin memiliki sensitivitas paling baik terhadap bakteri gram negatif sebanyak 83,2%. Penelitian ini menunjukkan bahwa bakteri yang paling banyak ditemukan pada urine pasien pasca PN adalah *E. coli* dengan meropenem dan amikasin adalah antibiotik paling sensitif. Walau demikian, terapi antibiotik pada pasien sebelum dan sesudah prosedur PN memerlukan pertimbangan bijak untuk mencegah resistensi PNCI.

Kata kunci: Antibiotik, bakterial, nefrostomi perkutan, sensitivitas

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Introduction

Nephrostomy is a procedure for urine diversion that involves the use of a tube, stent, or catheter. The instruments are inserted through a skin incision into the renal parenchyma and end in the renal pelvis or calix. Nephrostomy is performed in patients with acute urinary obstruction in upper urinary system.[1] Currently, two types of nephrostomy techniques are frequently applied, namely percutaneous nephrostomy and open nephrostomy. Open nephrostomy was done by inserting a catheter tube into the pyelum through the renal pelvis. The percutaneous nephrostomy involves the insertion of a tube through the skin into the renal pelvis using ultrasonography (USG) or fluoroscopy.[2] The goal of percutaneous nephrostomy is urinary diversion in obstructive conditions and to prevent acute renal impairment, especially in patients with malignancy around the urinary tract.[3]

Nephrostomy is a relatively safe and effective technique. Although relatively safe, it still has the nature of all other invasive procedures and carries potential complications. Bacteriuria is an almost inevitable consequence of percutaneous nephrostomy, such as pyelonephritis which, if left untreated, can lead to urosepsis.[1] The occurrence of infection or the percutaneous nephrostomy related infection (PCNI) is often predisposed by the decreasing immune system in patients with malignancy or in systemic treatment.[4] Urinary tract infections (UTIs) are closely related to the urological procedures performed, including nephrostomy procedure. Several studies have found an incidence of UTI up to 20% among patients receiving these procedures and infection associated with percutaneous nephrostomy of up to 19% and sepsis of 1.3 to 1.8% has been recognized.[4-6]

The occurrence of infection is influenced by the presence of bacterial virulence and host defense factors.[7] The germ virulence is strongly influenced by the type of germ and environment for colonization, adhesion, and invasion. Some of the things that must be kept in mind are the host defense mechanisms such as the hydrodynamic factors, dilution, washing and elimination of germs that pass with urine. The response to broad-spectrum antibiotics depends on the pattern of resistance and effectiveness of these antibiotics. Knowing the bacterial sensitivity to antibiotics can guide clinicians in providing an appropriate and safe treatment to reduce the incidence of infectious diseases. The use of antibiotics that are not appropriate for the existing resistance patterns can lead to bacterial resistance to the antibiotic. One of the principles behind the emergence and spread of resistance between bacteria is the prevalence of resistance which is directly proportional to the number of antibiotics used in various treatments.[8] This is illustrated by the increasing antibiotic resistance in some countries that do not limit antibiotic use.[9]

Although antibiotic resistance is not a new problem, the failure in addressing various factors causing bacterial resistance to antibiotics have made it a complex health problem. The number of resistant bacteria is increasing rapidly, and some pathogenic bacteria have resistance to several antibiotics, and even to all antibiotics. Some bacteria that have become resistant to first-line antibiotics will require more expensive second or third line antibiotics. Many factors influence the emergence of antibiotic-resistant bacteria.However, the important factors are the inappropriate use of antibiotics and infection control. Therefore, the wise use of antibiotics is very important, added by the implementation of good infection control to prevent resistant bacteria growth in the community.[9]

This study aimed to determine the suitability of antibiotics based on the results of culture and bacterial sensitivity and describe the bacterial patterns and antibiotic sensitivity tested on urine cultures of patients underwent undergone percutaneous nephrostomy at Dr. Hasan Sadikin General Hospital Bandung, Indonesia, in a three-year period of 2017–2019.

Methods

This research was a retrospective descriptive observational study on data from the medical records of patients with obstructive uropathy who underwent percutaneous nephrostomy in the period of January 2017 to December 2019 at the Urology Department of Dr. Hasan Sadikin General Hospital Bandung, Indonesia Data on age, gender, diagnosis, culture result, and bacterial sensitivity test to antibiotics were recapitulated and compared to the inclusion criteria. To avoid sample bias, all urine samples were collected from nephrostomy production since the urine passing down to urethral could be colonized with different bacteria along the urinary tract that are originated from other causes than from nephrostomy alone.

The inclusion criteria used in this study were patients diagnosed with obstructive uropathy

underwent percutaneous nephrostomy at the Urology Department of Dr. Hasan Sadikin General Hospital Bandung, Indonesia, during the period of January 2017 to December 2019; availability of patient's lab data, including the resuts of bacterial culture tests, bacterial sensitivity tests, and antibiotic resistance test results of bacteria found in the culture; complete demographic data in medical records, including patient's medical record number, name, age, gender, and medical history. Patients diagnosed with urinary tract infections, including pyonephrosis prior to percutaneous nephrostomy, were excluded. Ethical clearance was not required for this study.

Result

A total of 121 patients underwent percutaneous nephrostomy and had their culture and bacterial resistance tested after the nephrostomy during the period of January 2017 to December 2019. The age of these patients was 52.80±14.541 years with the range of 1 to 85 years. Most patients underwent percutaneous nephrostomy were those with enlarged kidneys due to the obstruction by urinary tract stones (28.7%), cervical cancer (12.3%), and bladder cancer (16.4%) The remaining patients underwent this procedure due to chronic obstruction caused by prostate disorders, urethral strictures, and other conditions. The general characteristics of the subjects in this study are listed in Table 1.

From 122 research subjects, 121 bacterial isolates were obtained. The characteristics of the bacteria isolated from urine culture in this study are shown in Table 2.

Table 1 Subject Characteristics

Variable	(n=121) (%)
Age (years)	
Average ±Standard deviation	52.80±14.541
Median	54
Gender n (%)	
Male	65 (53.3%)
Female	57 (46.7%)
Comorbidity n (%)	
Cervical cancer	15 (12.3%)
Urolithiasis	35 (28.7%)
Bladder cancer	20 (16.4%)
Prostate disorder	3 (2.5%)
Urethral stricturrre	3 (2.5%)
Others	46 (37.7%)

The characteristics of bacteria from the urine samples of the subjects are presented in Table 2. A total of 20 bacterial isolates were classified as gram-positive bacteria (16.5%) and 101 isolates were gram-negative bacteria (83.5%). The most frequently isolated bacteria were *E. coli* with 42 isolates, 22 isolates of *Pseudomonas aeruginosa,* and 20 isolates of *Klebsiella pneumoniae* for gram-negative bacteria. Ten isolates of gram-positive bacteria contained *Staphylococcus aureus*. The least frequently found bacterial isolates were those with *Salmonella* spp., only 5 isolates from all isolates of gram-negative bacteria.

Table 2 Bacterial Isolation Characteristic of Urine Sample

Bacteria	Gram	(n=121) (%)
Enterococcus faecalis	Positive	2 (10%)
Streptococcus agalactiae		2 (10%)
Streptococcus dysgalactiae		2 (10%)
Staphylococcus epidermidis		4 (20%)
Staphylococcus aureus		10 (50%)
Acinetobacter baumannii	Negative	2 (20%)
Escherinchia coli		42 (41.6%)
Klebsiella pneumoniae		20 (19.8%)
Morganella spp.		6 (5.9%)
Proteus mirabilis		2 (5.9%)
Providencia struartii		2 (2%)
Pseudomonas aeruginosa		22 (21.8%)
Salmonella spp.		5 (5%)

Table 3 Sensitivity Pattern of Gram-Positive Bacteria to Antimicrobials

	Antibiotics	Gram Positive Bacteria					
		Enterococcus faecalis n=2	*Staphylococcus aureus* n=10	*Staphylococcus epidermidis* n=4	*Streptococcus agalactiae* n=2	*Streptococcus dysgalactiae* n=2	Total n=20
Antibiotic sensitivity (%)	Vancomycin (VAN)	2 (100%)	10 (100%)	4 (100%)	2 (100%)	2 (100%)	20 (100%)
	Ceftriaxone (CRO)		10 (100%)	4 (100%)	2 (100%)	2 (100%)	18 (90%)
	Cefoperazone (CFP)		10 (100%)	4 (100%)	2 (100%)	2 (100%)	18 (90%)
	Clindamycin (CLI)	0 (0%)	10 (100%)	4 (100%)	2 (100%)	2 (100%)	18 (90%)
	Erithromycin (ERY)	0 (0%)	10 (100%)	4 (100%)	2 (100%)	2 (100%)	18 (90%)
	Meropenem (MEM)	0 (0%)	10 (100%)	4 (100%)	2 (100%)	2 (100%)	18 (90%)
	Amoxiclav (AMC)	2 (100%)	10 (100%)	4 (100%)	0 (0%)	0 (0%)	16 (80%)
	Ampicillin (AMP)	2 (100%)	10 (100%)	4 (100%)	0 (0%)	0 (0%)	14 (70%)
	Cefotaxime (CTX)		10 (100%)	4 (100%)	0 (0%)	0 (0%)	14 (70%)
	Ceftazidime (CAZ)		10 (100%)	4 (100%)	0 (0%)	0 (0%)	14 (70%)
	Ciprofloxacin (CIP)	0 (0%)	8 (80%)	0 (0%)	0 (0%)	0 (0%)	8 (40%)
	Levofloxacine (LVX)	0 (0%)	8 (80%)	0 (0%)	0 (0%)	0 (0%)	8 (40%)
	Amikacin (AMK)				2 (100%)	2 (100%)	4 (20%)
	Gentamicin(GEN)		0 (0%)	0 (0%)	0 (0%)	0 (0%)	0(0%)

Table 4 Sensitivity Pattern of Gram-Negative Bacteria to Antimicrobials

	Antibiotics	Gram Negative Bacteria								
		Acinetobacter baumannii **n=2**	***Escherinchia coli*** **n=42**	***Klebsiella pneumoniae*** **n=20**	***Morganella spp*** **n=6**	***Proteus mirabilis*** **n=2**	***Providencia struartii*** **n=2**	***Pseudomonas aeruginosa*** **n=22**	***Salmonella spp.*** **n=5**	**Total n=101**
Antibiotic sensitivity (%)	MEM	0 (0%)	38 (90.5%)	18 (90%)	6 (100%)	2 (100%)	0 (0%)	15 (68.1%)	5 (100%)	84 (83.2%)
	AMK	0 (0%)	37 (88.1%)	18 (90%)	6 (100%)	2 (100%)	2 (100%)	18 (81.8%)	0 (0%)	83 (82.2%)
	GEN	0 (0%)	33 (78.6%)	9 (45%)	0 (0%)	2 (100%)	0 (0%)	16 (72.7%)	0 (0%)	60 (59.4%)
	CAZ	0 (0%)	24 (57.1%)	5 (25%)	2 (33.3%)	0 (0%)	0 (0%)	14 (63.6%)	5 (100%)	50 (49.5%)
	CRO	0 (0%)	32 (76.1%)	5 (25%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)	2 (40%)	41(40.6%)
	SXT	2 (100%)	19 (45.2%)	9 (45%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	5 (100%)	37 (36.6%)
	AMP	2 (100%)	16 (38.1%)	3 (15%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)	5 (100%)	28 (27.7%)
	CTX	[redacted]	16 (38.1%)	3 (15%)	2 (33.3%)	2 (100%)	0 (0%)	0 (0%)	2 (40%)	25 (23.8%)
	CIP	0 (0%)	7 (16.8%)	5 (25%)	0 (0%)	0 (0%)	0 (0%)	8 (36.4%)	0 (0%)	20 (19.8%)

The antibiotic sensitivity test results for the isolates of both gram-positive and gram-negative bacteria are shown in Tables 3 and 4. Based on Table 3, vancomycin have the best sensitivity to gram-positive bacteria based on the results of antibiotic sensitivity tests to bacteria from urine culture of patients who underwent nephrostomy. Other antibiotics, i.e., ceftriaxone, cefoperasone, clindamycin, erythromycin, and also Meropenem, appeared to have good sensitivity in the urine culture isolates of patients who have undergone percutaneous nephrostomy. Both Ciprofloxacin and levofloxacin had 40% susceptibility to Gram positive bacteria in urine culture, while amikacin and gentamicin had 20% and 0% susceptibility to gram-positive bacteria found in urine cultures of patients who have undergone percutaneous nephrostomy, respectively.

For Gram negative bacteria, as seen in table 4, meropenem and amikacin were the antibiotics with the best sensitivity to Gram negative bacteria (83.2%). Meanwhile, gentamicin and ceftazidime had a fairly good sensitivity, reaching 59.4% and 49.5%, respectively. The antibiotics that was least sensitive to gram-negative bacteria was ciprofloxacin, with only 19.8% sensitive to gram negative bacteria, based on the results of the urine culture of patients who underwent percutaneous nephrostomy in this study.

Discussion

Nephrostomy is a procedure that is frequently used as a diversion option in many urological cases, including in malignancy or ureteral obstruction. Percutaneous nephrostomy is a primary diversion method as a preventive measure for renal failure in high-risk patients, especially cancer patients.[1] In this study, percutaneous nephrostomy was mostly performed in patients with obstruction due to urinary tract stones, followed by patients who experienced blockages due to malignancies such as cervical and bladder cancers. This is in line with the fact that the most prominent indications for percutaneous nephrostomy are urinary tract obstruction caused by urinary tract stones and malignancy.[9]

A systematic review conducted by Batura and Rao outlined some of the benefits of performing urine culture for nephrostomy. Most studies mention the use of urine culture to assist the selection of antibiotics for empiric therapy in sepsis.[10] Research by Watson et al. mentioned that there were differences in bacteria found in kidneys urine cultures obtained through the nephrostomy tube than those taken from the bladder. In the urine collected directly through nephrostomy, 116 (36.8%) additional pathogens were found, allowing to add necessary antibiotic prescription for the patient.[11]

One of the most prominent complications that might be found in nephrostomy is infection, e.g. pyelonephritis, which is a risk for urosepsis. Studies have shown that the incidence of urinary tract infections is up to 20% and the incidence of PCNI is as high as 19%.[1] Infectious complications often occur in relation with the patient's immune condition. In patients with impaired immunity, especially in patients with malignancy and patients on systemic treatment,the incidence of PCNI increases within the period of intervening nephrostomy placement for up to 90 days, which is the mean time to replace the conduit due to intraluminal obstruction and encrustation by debris.[12,13]

In around 14% of chronic obstruction cases, percutaneous nephrostomy related infection (PCNI) was identified.[3] A study by Dienstmann et al. reported 20% incidence of urinary tract infection in cervical cancer patients undergoing nephrostomy.[4] Another study by Bahu et al. examined the risk of PCNI in cancer patients. It was found that pyelonephritis occurred within 3 months and nearly 1 in 5 cancer patients who underwent nephrostomy.[3] A previous study by Maramara et al. stated that of 71 patients with pyelonephritis, 17 of them were asymptomatic.[14]

Percutaneous nephrostomy related infection (PCNI) is a risk of complications often occurs in patients undergoing nephrostomy procedures. In this study, most of the bacteria found in the urine culture of patients undergoing nephrostomy were under the classification of Gram negative bacteria, i.e., *E. coli* and *Pseudomonas* spp. This is in line with the findings of Maramara et al. that in pyelonephritis conditions, *Pseudomonas aeruginosa* and *Enterococcus faecalis* are the most common bacteria found in culture. Yet, this result is different from the study conducted by Bahu et al. who found that most of the incidence of pyelonephritis (48%) was caused by Gram positive bacteria and was similar to the culture findings of central line associated blood stream infection (CLABSI). The bacteria that cause percutaneous nephrostomy tube related infection and CLABSI are similar in that they are both commensal bacteria on the skin that gain access to the urinary tract and blood vessels through percutaneous catheters.[3]*Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Escherichia coli* found in this study are known as device-

related biofilm infection.[13]

Percutaneous nephrostomy is a well-known clean contaminated procedure, so prophylactic antibiotics are highly recommended.[15] Bahu et al. revealed that the strongest risk factor for PNCI was a history of previous urinary tract infections. More than half of PNCI events occur within 40 days after the insertion of percutaneous nephrostomy.[3] As stated by Batura and Rao, there are currently no specific guidelines that recommend antibiotic administration at the time of nephrostomy tube replacement.[10] The antibiotics commonly used are cefazolin, ceftriaxone, ampicillin sulbactam, gentamicin, vancomycin, clindamycin, and the penicillin class.[15] The fluorocluinolone class of antibiotics (ciprofloxacin) had poor sensitivity in this study. This is in line with other studies and is probably due to the number of prescriptions given to patients for these antibiotics without following good guidelines which then contributes to the development of resistance.[16]

In the gram-positive group, the most sensitive antibiotics is vancomycin, a glycopeptide class of antibiotics, that is indicated for treatments of conditions caused by methicillin-resistant (beta-lactam-resistant) staphylococci. Ceftriaxone and cefoperazone are two antibiotics commonly provided in Dr. Hasan Sadikin General Hospital as an empirical treatment in post-nephrostomy patients. Both were found to have a 90% sensitivity to the gram-positive bacteria found in the patient's urine culture results. In accordance with the therapeutic recommendations of UAE, the administration of an empiric therapy has good effectiveness in complicated urinary tract infections associated with catheter placement. Ceftriaxone and cefoperazone are the categorized as the third generation cephalosporin class antibiotics. Both antibiotics are semisynthetic broad-spectrum antibiotics that are effective in the treatment of pseudomonas. Antibiotics of this class are well known and sensitive to various types of bacteria commonly found in respiratory infections, peritonitis, and skin infections.[17]

In the Gram-negative group, the antibiotics with the best sensitivity are meropenem and amikacin. Meropenem is a carbapenem (beta-lactamase inhibitor) class antibiotics that has a broad spectrum. This class of antibiotics has good effectiveness on Gram-negative rods, including *P. aeruginosa*, Gram-positive, and anaerobic bacteria. Amikacin is an aminoglycoside class of antibiotics that is used in combination to treat infections that have broad spectrum resistance.[17]

This study carries limitations in that it was a retrospective study and only covered one health service location without follow-up on subjects regarding the provision of culture-appropriate antibiotics.

In conclusion, *Eschericia coli* is a bacterial isolate most commonly found in urine cultures of patients undergoing percutaneous nephrostomy in Dr. Hasan Sadikin General Hospital Bandung, Indonesia, during the period of January 2017 to December 2019. Most bacterial isolates include bacteria commonly found in the urinary tract and digestive tract with the addition of Gram-positive bacteria which are the normal flora of the skin, such as *Staphylococcus aureus*. The antibiotic therapy most widely used in post-nephrostomy patients is cefoperazone. This therapy is sensitive for Gram-positive bacteria. This antibiotics is combined with amikacin which is sensitive to Gram-negative bacteria. Antibiotic therapy in patients who were about and have undergone percutaneous nephrostomy requires careful considerations and wise judgment to prevent bacterial resistance and percutaneous nephrostomy related infection (PNCI).

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