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Review Article

Urinary Tract Infection and its Management

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ABSTRACT
Cleanness accompany every measures of disinfection and sterilization. Infection mainly develops from improper sanitation. Among the universal infectious diseases which increases the economic burden on the society, Urinary tract infection is the most common one that influence organs concerned to the urinary system i.e. ureter, bladder, urethra along with kidney. Urinary tract infections can occur by Gram-negative as well as Gram-positive bacteria and through some Fungus. The ultimate prevailing biological pathogen is uropathogenic *Escherichia coli* (UPEC). Among the micro-organisms causing uncomplicated UTIs, UPEC is predominant followed by *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Staphylococcus saprophyticus*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, group B *Streptococcus* (GBS), *Candida* spp. and *Proteus mirabilis*. Pathogens causing UTI mainly enter to our body from the toilet seat. For the treatment of UTI various plants are used in the conventional system of medicine including *Azadirachta indica*, *Nyctanthes arbor-tristis*, *Ocimum sanctum*, *Curcuma longa*, *Terminalia chebula* etc. In addition to this various antimicrobials are there which are used for the treatment of UTI. However the preventive measures include sterilization and disinfection through various chemical agents. The list of disinfectants include formaldehyde, glutaraldehyde, ethanol, hydrogen peroxide, per acetic acid, sodium hypochlorite and quaternary ammonium compound etc. having different minimum inhibitory concentration range against the UTI causing pathogens. The use of disinfectants can be encouraged towards an effective prevention of UTIs.
Key words: Disinfectants, Minimum inhibitory concentration, Urinary tract infection.
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INTRODUCTION

Cleanness is the method of elimination and minimization of dirtiness to sustain the prominence of the materials by lowering bacterial inhabitants. The cleanliness should involve disinfection and sterilization.[1] Mainly infection develops from improper sanitation. According to the theories of sanitation, infections are spread by association of uninfected people with infected ones.[2] Infection results from the forced entrance of disease-causing organisms into the host body and their reproduction which leads to the generation of toxins by their reaction with the host body tissues.[3]

Among the universal infectious diseases which increases the economic burden on the society, Urinary tract infection is the most common one.[4] A urinary tract infection (UTI) is a disease that influence organs concerned to the urinary system i.e. ureter, bladder, urethra along with kidney. Infections mainly occur in the lower urinary tract i.e. in the urinary bladder along with the urethra. Every year about 150 million individuals are suffered with UTI worldwide.[5] According to a survey conducted in United States, about 10.5 million people visit hospital for Urinary tract infection including 0.9% of ambulatory cases and 2-3 million of emergency cases.[6-8]

PATHOGENESIS OF URINARY TRACT INFECTION

The presence of sufficient and un-objectionable clinical and experimental evidence indicates that Urinary tract infection is four times more familiar in female than male. Microorganisms can make an entrance into the renal system by transmission through the blood or lymph and through the urethra. But the entry of micro-organism through urethra is the primary reason of UTI, exclusively for enteric bacteria or bacteria of intestine (such as *Escherichia coli* and micro-organisms belong to family Enterobacteriaceae). It contributes towards the greater chances of women affecting with UTI. Also, the bladder catheterisation or instrumentation raise the risk of infection. After catheterization bacteriuria is found in nearly all patients within 4 weeks due to the migration of bacteria inside the mucopurulent space among the urethra and catheter. The hematogenous infection results from some bacteria which develop early infection somewhere else in the body. Also, the pathogenicity of UTI rely upon the natural defense mechanism of the body.[4]

TYPES OF UTI

Urinary tract infection is divided into different types based on anatomy of parts infected (Table 1), grade of severity of infection (Table 2), risk associated to it (Table 3) and different microbiological findings. According to microbiological findings it is classified as following.[4]

1. Susceptible
2. Reduced susceptibility
3. Multi-resistant

It is also categorized as complicated and uncomplicated UTI. If the excretion urography is normal, not associated with any disease and there is no kidney damage, then it is called uncomplicated UTI. If the excretion urography is normal or abnormal with associated diseases like diabetes mellitus, sickle cell diseases/trait and conditions like analgesic abuse, NSAID abuse or if the excretion urography is abnormal with stones, obstructions, vesicoureteric reflux and having a risk of kidney damage & septicemia, then it is termed as complicated UTI.[9] In females, cystitis and pyelonephritis are common type of urinary tract infections where as in male urethritis and prostatitis are very common.

RISK ISSUES ALLIED WITH UTI

Some of the risk issues allied with UTI are old age, inappropriate diet, aggravated immune response, diabetes mellitus, smoking, heavy weight, simultaneous infection at an inaccessible location, deficiency of regulation of risk issues, lengthy visit to clinic before operation preferentially current hospitalization, past or persistent genitourinary infection, surgical procedure concerning with bowel section, formation of colony with microbes, enduring drainage, urinary blockade and urinary stone.[4]

Table 1 : Based on anatomy of part infected

Infected organ	Kind of disease
Urethra	Urethritis (UR)
Urinary bladder	cystitis (CY)
Kidney	pyelonephritis (PN)
Bloodstream	sepsis (US)

Table 2: Grade of severity of infection

Grade of severity	Kind of disease
Low	Cystitis
Moderate	Pyelonephritis
Severe, established	Pyelonephritis
SIRS	Bloodstream sepsis (US)
Organ dysfunction	Bloodstream sepsis (US)
Organ failure	Bloodstream sepsis (US)

Table 3: Risks associated with UTI

Category risk factor	Type of infection
No Risk factor	O
Recurrent UTI Risk factor	R
Extra urogenital Risk factor	E
Nephropathic Risk factor	N
Urological Risk factor	U
Catheter Risk factor	C

CAUSATIVE ORGANISMS OF UTI

Urinary tract infections can be caused by Gram-negative as well as Gram-positive bacteria and through some Fungus. The ultimate prevailing biological pathogen is uropathogenic *Escherichia coli* (UPEC). Among the micro-organisms causing uncomplicated UTIs, UPEC is predominant followed by *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Staphylococcus saprophyticus*, *Pseudomonas aeruginosa, Enterococcus faecalis*, group B *Streptococcus* (GBS), *Candida* spp. and *Proteus mirabilis*.[8-12]

Escherichia coli

E. coli is the gram-negative organism of genus Escherichia found in the lower intestine of endotherms. These are the rod shaped bacterium which are facultatively anaerobic.[13] Maximum *E. coli* strains are inoffensive, but in the host certain serotypes form the basis of severe food poisoning and sometimes accountable for product recalls as a result of food adulteration.[14] Within the fecal matter *E. coli* is ejaculated into the surroundings. The bacterium matures hugely in fresh faeces within aerobic circumstances for 3 days, however its quantities drop subsequently.[15] *E. coli* strains can cause gastroenteritis, urinary tract infections and neonatal meningitis. It is also responsible for serious abdominal cramps, diarrhea that characteristically goes bloody in 24 h, as well as occasionally increases temperature. Within sporadic circumstances, contagious strains are too liable for necrotizing enterocolitis (NEC) and damage excluding continue hemolytic anemia and thrombocytopenia, inflammation of the peritoneum, inflammation of the breast, bacteremia and gram-negative pneumonia.[16]

Klebsiella pneumoniae

Klebsiella spp. are ubiquitous or pervasive organism having two common habitats, one is surface water, sewage and soil and another is plants.[17] *K. pneumoniae* is a gram-negative bacteria exist as a saprophyte in the nasopharynx and intestinal tract of human body. *Klebsiella pneumoniae* are the root cause of Nosocomial Klebsiella infections, UTI, Pneumonia, Septicemia, Wound infections and Neonatal septicemia.[18] The typical location of contamination is the urinary tract. Klebsiella is responsible for 6 to 17% of all nosocomial urinary tract infections (UTI) and in definite sets of victims, e.g., individuals having neuropathic bladders or having diabetes mellitus show even greater risk of incidence.[19]

Staphylococcus aureus

Staphylococcus aureus is a gram-positive facultative aerobe and is capable to develop in absence of oxygen by fermentation or by means of an alternative electron acceptor. Numerous studies recommend that pathogenicity of *S. aureus* relay upon oxygen, as oxygen plays a vital role in producing virulence factor and survival of the organism in extreme environmental conditions.[19] It is often established within the respiratory tract of the person as well as over the skin surface. It is optimistic for reduction of catalase and nitrate. Though *S. aureus* is not every time virulent, it is a casual reason of epidermal diseases (e.g. boils), respiratory abnormalities (e.g. sinusitis) and food poisoning. Infections are frequently promoted by disease-associated strains by generating potent protein toxins and conveying proteins of the cell-surface that attach and deactivate antibodies. Strains of *S. aureus* in their host phages, such as Φ-PVL (yields Panton-Valentine leukocidin), increases the virulence. *S. aureus* is very widespread in personnel with atopic dermatitis.[20] Urinary tract infection is infrequently produced by *Staphylococcus aureus* in the general population. In definite patients, *S. aureus* results in ascending urinary tract colonization and infection. Instrumentation of urinary tract in addition to urethral catheterization rise the threat of *S. aureus* presence in the urinary tract.[20-22]

Enterococcus faecalis

These are the gram positive, facultatively anaerobic organisms having ovoid shape. They come out in tiny chains in both sets or by means of distinct cells on the smear. *E. faecalis* are catalase negative since they do not contain cytochrome enzymes like streptococci and, even if some strains do produce pseudo catalase.[23] They have the characteristics like the capability to breed in 6.5% NaCl and at pH 9.6, to propagate at 10 and frequently 45°C and intended for the maximum portion, to persist at 60°C for 30 min.[24,25] Enterococci are the primary cause of UTIs, primarily among hospitalized patients. Enterococcal prostatitis and perinephric abscess are also reported. Frequent infections and structural anomalies are not seen in young healthy females who have not gone through instrumentation. Enterococci is responsible for <5% of UTIs.[23]

Pseudomonas aeruginosa

Pseudomonas aeruginosa is a pervasive Gram-negative microbe isolated from earth, water and plants. Also, it is an opportunistic human pathogen which communicates disease to immunodeficient or otherwise compromised individuals. Several virulence factors including Exotoxin A, elastase and phospholipase Care possessed by *P. aeruginosa*. For the first time, these are identified biochemically according to their cytotoxic activity.[26] *P. aeruginosa* have multiple virulence factors and accompanied cell allied aspects such as lipopolysaccharide (LPS), flagellum, alginate, pilus and non-pilus adhesins including extracellular enzymes or secretory virulence features such as elastase, hemolysins (rhamnolipids), phopholipase, protease, exotoxin A, pyocyanin, exoenzyme S and siderophores. These aspects show a major part in pathogenesis of infections

caused by *P. aeruginosa* such as respiratory tract infections, burn wound infections and keratitis.[27] Woods *et al*. state that strains isolated from urinary tract infection site indicate immense production of elastase and protease in comparison to isolates of other infections site.[28] Thus, *P. aeruginosa* stands as the third most conversant microbe allied with hospital-acquired catheter associated UTIs.[29]

Proteus mirabilis

Proteus mirabilis is a Gram-negative, rod shaped bacterium belonging to the family Enterobacteriaceae (same as *E. coli*). It is motile, urease positive, lactose-negative, indole-negative and produces hydrogen sulfide. It is a pathogen most often present in the urinary tract, predominantly in patients experiencing enduring catheterization. *P. mirabilis* is capable of initiating characteristic contagions of the urinary tract comprising cystitis and pyelonephritis. It is found in case of asymptomatic bacteriuria, typically in the older patients with type 2 diabetes. These infections are also responsible for bacteremia and further developed to potentially dangerous urosepsis. Furthermore, *P. mirabilis* infection is responsible for producing urinary stones (urolithiasis). About 1-10% of all urinary tract infections are caused by *P. mirabilis*.[30]

Candida albicans

Candida albicans is a highly polymorphic fungus which can switch *in vivo* to alternative vegetative growth forms as a result of altering environmental circumstances such as nutrient availability, temperature, pH, CO_2 and the presence of serum. This phenotypic flexibility is a vital virulence factor. It gives assistance in the invasion of epithelia, propagation all over the host and survival in various host environments and assists to modulate the host immune response and counteract immune surveillance. No environmental reservoirs are known. It is conveyed from mothers to neonates and by nosocomial infection. *Candida albicans* is usually an inoffensive commensal of human beings, however it results in external infections of the mucosa (oral/vaginal thrush) in healthy individuals and (infrequently) infections of the skin or nails. In immune-compromised hosts, furthermore it become offensive by triggering deadly systemic as well as bloodstream infections, where as the mortality rate can be as high as 50%. It is the utmost common reason of serious fungal infection and is a prime source of nosocomial infections in hospitals.[31] It is also a cause of candiduria. Fluconazole is ideal for the management of Candida UTIs. Flucytosine is concentrated in urine and has wide range of effects against *Candida* spp, however its usage needs carefulness due to its toxicity. Small dose of amphotericin B

Table 4: MIC of various disinfectants

Name of Disinfectant	Micro-organism	MIC
Formaldehyde (0.5 to 1% aqueous solution)	*S. marcescens*	58.5 mg/L
	E. cloacae	117mg/L
	S. aureus	156mg/L
	E. coli	156mg/L
	B. subtilis	235mg/L
	B. stearothermophilus	246mg/L
Gluteraldehyde	*B.subtilis*	2750-3750mg/L
	A.calcoaceticus	2750-3750 mg/L
	E. cloacae	2750- 3750 mg/L
	E. coli	2750- 3750 mg/L
	S. marcescens	1375- 1875 mg/L
	S. aureus	1375- 1875 mg/L
	B. stearothermophilus	1375- 1875 mg/L
Ethanol	*B. stearothermophilus*	87500 mg/L
	B. subtilis	87500 mg/L
	S. aureus	87500 mg/L
	E. cloacae	87500 mg/L
	E. coli	65650 mg/L
	S. marcescens	43750 mg/L
	A. calcoaceticus	43750 mg/L
Hydrogen peroxide (4%)	*B.subtilis*	1875mg/L
	B. stearothermophilus	1875 mg/L
Per acetic acid (3%)	*B.subtilis*	0.9-1.85%
	S.aureus	0.46%
	B. stearothermophilus	0.46%
Sodium hypochlorite	*E.coli*	1129 mg/L
	spore	4491 mg/L
Quaternary ammonium compound	*B. subtilis*	47 mg/L
	B. stearothermophilus	156 mg/L
	E. coli	59-78 mg/L
	S. aureus	59-78 mg/L
	S. marcescens	59-78 mg/L
	E.cloacae	59-78 mg/L
	A. calcoaceticus	9.77 mg/L

may be beneficial for Candida UTIs in certain patients.[32]

DISINFECTANTS EFFECTIVE AGAINST UTI CAUSING ORGANISMS

Disinfectants are antimicrobial agents that are implemented on the surface of inert substances in order to eradicate microorganisms that are present on the substances. Several disinfectants very effective against the pathogens causing UTI are given below along their MIC against different micro-organisms (Table 4).[33]

Formaldehyde (CH_2CO)

Formaldehyde is having disinfectant and airborne sanitization property because of its antimicrobial (sporicidal, virucidal, fungicidal) activities. It is a colorless gas with bitter odor. It is soluble in water, ethanol and chloroform; miscible with acetone, benzene and diethyl ether. Marketable formaldehyde–alcohol solutions are stable; the gas is stable in absence of water; incompatible with oxidizers, alkalis, acids, phenols and urea. 0.5–1% formaldehyde solutions triggered a reduction of 6–9 log10 after 8 h of interaction.[1] The loss of activity in the existence of organic substance as well as its carcinogenic prospective are the major disadvantage of formaldehyde. It may also cause eczema and sensitization.[34]

Gluteraldehyde ($C_2H_8O_2$)

Glutaraldehyde is an important dialdehyde which is used as a disinfectant and sterilant. Its mechanism involves cross-linking of proteins within the cell membrane in addition to somewhere else inside the cell (Table 5).

Gluteraldehyde is a chemical compound applicable for high level sterilization, because it reduces the culture of sporulated microbes. It does not interact with synthetic substances or detergents. It is non-hazardous and does not clot proteins that may be found on the exterior of the article being sterilized. Yet, it is lethal and results in mucosal, skin and eye irritation.[1]

Ethanol (C_2H_5OH)

Ethanol is a volatile, colorless liquid that has a slight odor. Ethanol is an adaptable solvent, miscible to water in addition to various organic solvents, along with diethyl ether, ethylene glycol acetic acid, carbon tetrachloride, pyridine and toluene chloroform, glycerol, acetone, benzene nitro methane. Alcohols have prompt broad-spectrum antimicrobial action contrary to vegetative bacteria (involving mycobacteria), viruses, as well as fungi however not sporicidal. On the other hand, they inhibit sporulation and spore germination. Ethyl alcohol is more potent against viruses. In general, it leads to membrane impairment and fast denaturation of proteins that lead to hindrance in metabolism followed by cell lysis. Denaturation of *Escherichia coli* dehydrogenase as well as an amplified lag phase in *Enterobacter aerogenes* supports this specific report. It takes place by prevention of metabolism mandatory for rapid cell division.[33] The manifestation of glycerin (2%), prevent skin damage through the effect of alcohol, declines the action of ethanol in certain strains, excluding for *E. cloacae* and *S. aureus*. The addition of 10% iodine leads to reduction of the MIC of ethanol to 43750 mg/L for *B. subtilis* and *E. cloacae;* and to 21870 mg/L for *S. aureus*. Alcoholic solutions have also been added to other disinfecting agents like chlorhexidine, formaldehyde and povidone iodine, to avoid the contamination with gram-negative bacteria which are found in the hospital atmosphere.[1] Pure ethanol will aggravate the skin as well as eyes.[35] Nausea, vomiting and intoxication are the symptoms of ingestion. The consequence of long-term usage by ingestion is serious liver impairment.

Hydrogen peroxide (H_2O_2)

Hydrogen peroxide (H_2O_2) stands as a broadly utilized chemical agent meant for disinfection, sterilization, as well as antisepsis. It is found in the market as a clear, colorless fluid in different concentrations range starting from 3 to 90%. Hydrogen peroxide is eco-friendly, since it is capable of quickly degrading to the harmless byproducts like water and oxygen. Though most of the pure solutions contain stabilizers to avoid deterioration, hence they retained their stability. It shows wide-spectrum of activity for virus, bacteria, yeasts, as well as bacterial spores.[36] Generally the effect is more against gram-positive than gram-negative bacteria. More concentrations of Hydrogen peroxide (10 to 30%) in addition to extended interaction periods can be necessary to produce sporicidal effect.[37] Typical solution of 4% H_2O_2 (40000 mg/L) instigated reduction in populations greater than 8 log10. The residual strains experimented have shown less resistance, by means of a MIC ranging from 469 to 1250 mg/L. It stands as a powerful oxidizer, harmless and also handled easily.[1] Sagripanti and Bonifacino (1997) confirmed the sporicidal activity of H_2O_2 solution within a concentration of 10%, though the existence of organic matter cannot drop its effectiveness; smaller concentrations have also verified sporicidal activity after a longer period of interaction.[36]

Peracetic acid (CH_3COOOH)

It is a colorless fluid having a distinct pungent aroma significant to acetic acid. It is extremely corrosive. Peracetic acid (PAA) (CH_3COOOH) is a very powerful biocide as compared to hydrogen peroxide. In a very small concentrations (0.3%) it has sporicidal, bactericidal, virucidal and fungicidal effect.[36] Peracetic acid perhaps degrade proteins and enzymes as well as hike the cell wall penetrability by disturbing sulfhydryl (™SH) along with sulfur (S™S) links.[36,38] It is strictly irritating, as well as form explosive mixtures using quickly oxidizable metals.

Table 5: Mechanism of antimicrobial effect of glutaraldehyde

Target microorganism	Glutaraldehyde action
Bacterial spores	Small concentrations prevent proliferation; sporicidal in elevated concentrations, perhaps as a result of vigorous interaction with exterior layers of the cells.
Mycobacteria	Activity is unidentified, however maybe includes mycobacterial cell wall
Other nonsporulating bacteria	Strong alliance with external layers of gram-positive and gram-negative bacteria; cross-linking of amino groups in protein; blockage of transportation into cell
Fungi	Fungal cell wall emerge as a vital target spot, through proposed collaboration with chitin
Viruses	Genuine mechanisms is unidentified, however comprise of protein-DNA cross-links as well as capsid alterations
Protozoa	Mechanism of action unknown

Sodium hypochlorite (NaOCl)

Sodium hypochlorite solutions are extensively applicable as hard-surface disinfectant (domestic bleach). It can be utilized for disinfection of discharges of plasma having human immunodeficiency virus or HBV.[33] Same MIC ranges can be detected for the experimented microbes, while considering the preliminary concentration of free chlorine ranging from 8000-9000mg/L. Sodium hypochlorite is employed as base of disinfectants, presenting an ample spectrum of antimicrobial activity in varied temperatures. This compound is of easy access and handling, is not toxic and is compatible with detergents.[1]

Quaternary ammonium compounds

Quaternary ammonium compounds (QACs) act as very beneficial antiseptics as well as disinfectants.[39] Occasionally these are recognized as cationic detergents. Quaternary ammonium compounds are utilized in several medical prospects (e.g., preoperative disinfection of uninterrupted skin, use to mucous membranes and disinfection of noncritical surfaces). Furthermore, it has antibacterial effects, QACs are too tremendous for hard-surface cleansing as well as deodorization. They target the cell (inner) membrane and comprehensive membrane impairment including phospholipid bilayers. Small concentrations disturb membrane reliability, more concentrations lead to coagulation of cytoplasm.[40] They have sporicidal effects. They hinder the development of microbes and the spore germination.[33]

Phenol (C_6H_5OH)

Phenolic-type antimicrobial compounds have been utilized over a prolonged period of time for their antiseptic, disinfectant or preservative characteristics, based upon the compound. They were often denoted as "general protoplasmic poisons". They are having membrane-active characteristics that too contribute towards their total action.[41]

DIFFERENT PLANTS USED IN THE TREATMENT OF UTI

Neem (*Azadirachta indica*)

It is commonly termed as 'India Lilac' or 'Margosa', comes from the subfamily Meloideae, family Meliaceae. Various parts (bark, leaves, flowers, seed, fruits, oil, neem cake and gum) of the neem plant are utilized as traditional Ayurvedic remedy within our country. Neem oil, bark as well as leaf extracts are medicinally applicable as traditional drug for controlling intestinal helminthiasis, leprosy, constipation and respiratory disorders. Also, it improves the health of the human being. Neem oil remains useful for regulating several skin diseases. Root, bark, flower, leaf and fruit collectively treat the biliary diseases, blood morbidity, eczema, burning sensations, skin ulcers and phthisis.[42-43] Active ingredients are up to some extent soluble in water and freely soluble in organic solvents such as alcohols, these ingredients include: azardirachtin, 1-maliantriol, salannin, nimbin, nimbdin.[43] In another study, neem extract is effective against *S.aureus* but not against *E.coli.* Ethanol extracts were more effective in all cases whether for dry and fresh neem barks and leaves. Fresh leaves are more effective as compared to dry leave. Bark shows similar results.[44]

Parijat (*Nyctanthes arbortristis*)

Nyctanthes arbor-tristis Linn. is a renowned therapeutic plant in conventional system of medication belongs to the family Oleaceae. Its leaves contain β sitosterol, D-mannitol, flavonol, astragalin, glycosides, sitosterolnicotiflorin, nyctanthic acid, oleanolic acid, tannic acid, methyl salicylate, ascorbic acid, an amorphous resin, an amorphous glycoside, small quantity of volatile oil, friedeline, carotene, lupeol, mannitol, glucose, iridoid glycosides, fructose as well as benzoic acid.[45] Leave juice can be utilized as digestives, mild bitter tonic, remedy for reptile venoms, diaphoretic, laxative and diuretic.[46] Beside this leaves are useful in treating the splenomegaly. Conventionally the crushed bark is helpful in the management of malaria, rheumatic joint pain and cough. The plant is also having antihistaminic property, CNS activities (i.e. tranquillizer, antidepressant and hypnotic), local anesthetic, antiviral, anti-trypanosomal, anti-inflammatory, analgesic, antipyretic, amoebicidal, antiulcer, anthelmintic as well as immunomodulatory property.[47] Leaf extracts are having antibacterial property.[48] According to Verma *et al*., 2011 all the extracts from the bark possess anti-bacterial activities against *Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Streptococcus facecalis as well as Staphylococcus aureus*. Chloroform extract of *N. arbortristis* displayed higher zone of inhibition as compared to the aqueous, petroleum ether and ethanolic extracts.[46] According to Dhane *et al*., 2016 methanolic extract of *Nyctanthes arobortristis* prepared by ultrasonication method was found to possess excellent antibacterial activity against E. coli.[45]

Tulsi (*Occimum sanctum*)

Ocimum sanctum stands as a medicinal herb containing antibacterial property against numerous microbes with antibiotic resistance. It also possesses the anticancer, antidiabetic property.[49] It contains essential oils as well as aromatic composites. It is a gastronomic herb and an eye-catching, aromatic decorative shrub. *Ocimum* reduce lipid peroxidation and enhance the effect of superoxide dismutase.[50] The components of *Ocimum* class possess antibacterial, antifungal, antioxidant as well as radio protective effects.[51,52] Several species of *Ocimum* are beneficial for the management of diseases of the central nervous system (CNS) like depression.[53,54] Phytochemical analysis of *Ocimum* indicates the presence of phenolic compounds, glycosides, flavonoids, tannins and saponins, thus it is used as medicinal plant. Definite antimicrobial effects are witnessed for herb tulsi having MIC of 20mg/ml for *E-coli, Salmonella typhi and Vibrio cholerae*. After 30 min of interaction, the plant displayed enhanced antimicrobial effects against all three bacterias.[55] According to Prasad *et al*., 2012 isoamyl extract revealed stronger and wide range of antibacterial effects in comparison to other solvent extracts.[53]

Turmeric (*Curcuma longa* L.)

Turmeric (*Curcuma longa* L.), family Zingiberaceae, is a perennial rhizomatous bush mainly found in Southern Asia.[56] In India it is widely recognized as "Haldi" and is broadly cultivated in all parts of India (Pharmacopoeia I, 1996). The creeping root stalks of the shrub are oblongonate, pear shaped, mostly having small branches. Also, it is a domestic medication in Nepal.[57] Turmeric in its powder form regularly used due to its essence, like a spice in both vegetarian and nonvegetarian cooking. In addition to this it also has digestive effects. *Curcuma longa* extract contain alkaloids, tannin, flavonoid, glycoside and carbohydrate. Alkaloids and flavonoids are responsible for the antibacterial effects of plants.[58] Gupta *et al*., 2015 revealed that *C. longa* rhizome are highly active against standard and clinical isolates of *S. aureus* showing zone of inhibition ranging between 9 mm and 21 mm. Additional observations showed that benzene extract was least active showing zone of inhibition of about 9 mm at concentration of 50 mg/ml while methanolic extract was most active showing zone of inhibition of about 19 mm at the concentration of 50 mg/ml. Also different extracts (petroleum ether, methanol etc.) of *C. longa* rhizome was more effective antimicrobial agents than the crude extract of *C. longa*.[59] A study done by Singh *et al*., 2002 proposes that essential oil portion of turmeric possesses substantial ($P<0.001$) antimicrobial property in a small concentration (20 mg/disc) on pathogenic Grampositive *S. aureus* (CI) microbe.[60]

Chebulic Myrobalan (*Terminalia chebula*)

Terminalia chebula Retz. (Combretaceae) is indigenous to southern region of Asia including India, Pakistan, Nepal and the South-West of China extending from Kerala in south or even Srilanka.[61] According to Unani system of medicine, unripe fruit is an astringent and aperient. The ripe fruit is purgative, tonic, good in piles, strengthens the brain, the eyes and gums. In Ayurveda, fruits are used as antimicrobial,[62] antioxidant,[63] anti-inflammatory, wound healing, stomachic, laxative, tonic, carminative, expectorant, anthelminitic, antidysentric, useful in asthma, sore throat, eye and heart diseases, tumors, epilepsy, cures spongy gums, ulcers, snake bite and scorpion sting,[61] burns, skin disorders.[64] According to Hogade *et al*., 2011 the aqueous fruit extract of *Terminalia chebula* Retz showed significant activity against a pair of Gram-positive microorganisms (*Bacillus aureus* and *Staphylococcus aureus*) as well as three Gram-negative bacteria (*Pseudomonas aeruginosa, K. pneumonia, Escherichia coli,*). The aqueous fruit extract of *Terminalia chebula* is more significant against *S. aureus*. The aqueous extract at 100µg/ml concentration was most significant as compared to the standard drugs 25µg/ml Gentamycin as well as 25µg/ml Tetracycline against all organisms. The antibacterial activity is because of the presence of chemical constituents like saponins, alkaloids, tannins, tannic acid, glycosides, cardiac glycosides as well as simple phenolic substances.[65]

DIFFERENT ANTI-BACTERIALS USED IN THE TREATMENT OF UTI

Following anti-bacterials are used systemically for treatment of UTI.

1. Sulphonamides like sulfamethoxazole in combination with Trimethoprim
2. Aminoglycoside antibiotics like Gentamycin, Amikacin
3. B- lactam antibiotics like Ceftizoxim, Ceftriaxone, Ceftazidime and Penicillin G
4. Quinolones and fluoroquinolones like Nalidixic acid, Norfloxacin, Ciprofloxacin
5. Miscellaneous: Nitrofurantoin, Vancomycin and Erythromycin etc[66]

CONCLUSION

Urinary tract infection is mainly caused by micro-organisms like *E. coli, S.aureus* and *Klebsiella* etc. In addition to anti-bacterials different plants like neem, tulsi, turmeric, *parijat*, *chebulic myrobalan* etc. possess antibacterial property. Phenol, formaldehyde, gluteraldehyde, peracetic acid, hydrogen peroxide, quaternary ammonium compounds etc. are the disinfectants used mostly to prevent UTI.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

CNS: Central nervous system; **HBV:** Human immunodeficiency virus; **MIC:** Minimum inhibitory concentration; **NSAID:** Non-steroidal anti-inflammatory drug; **PAA:** Per acetic acid; **PVPI:** Povidone iodine; **QAC:** Quaternary ammonium compounds; **UPEC:** Uropathogenic *Escherichia coli*; **UTI:** Urinary tract infection.

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