ANTIMICROBIAL AND CLINICAL MICROBIOLOGY GUIDEBOOK

Third edition

July 2016

TABLE OF CONTENTS

ANTIMICROBIAL AND CLINICAL MICROBIOLOGY GUIDEBOOK

2016

INTRODUCTION

This is the Third Edition of the Antimicrobial and Clinical Microbiology Guidebook at Lawrence Memorial Hospital. The development of this guidebook has been a joint effort of the Antimicrobial Stewardship Program, Infectious Disease and Prevention, Pulmonology Specialist Group, Pharmacy, and the Microbiology Department. The purpose of the booklet is to optimize antimicrobial usage and patient outcomes for infectious disease-related issues.

Every effort has been made to ensure that the information is complete, accurate, and up to date; however, this booklet does not serve as a substitute for clinical judgment or consultation with experts in Infectious Diseases. Application of this information to each clinical situation is the responsibility of the practitioner.

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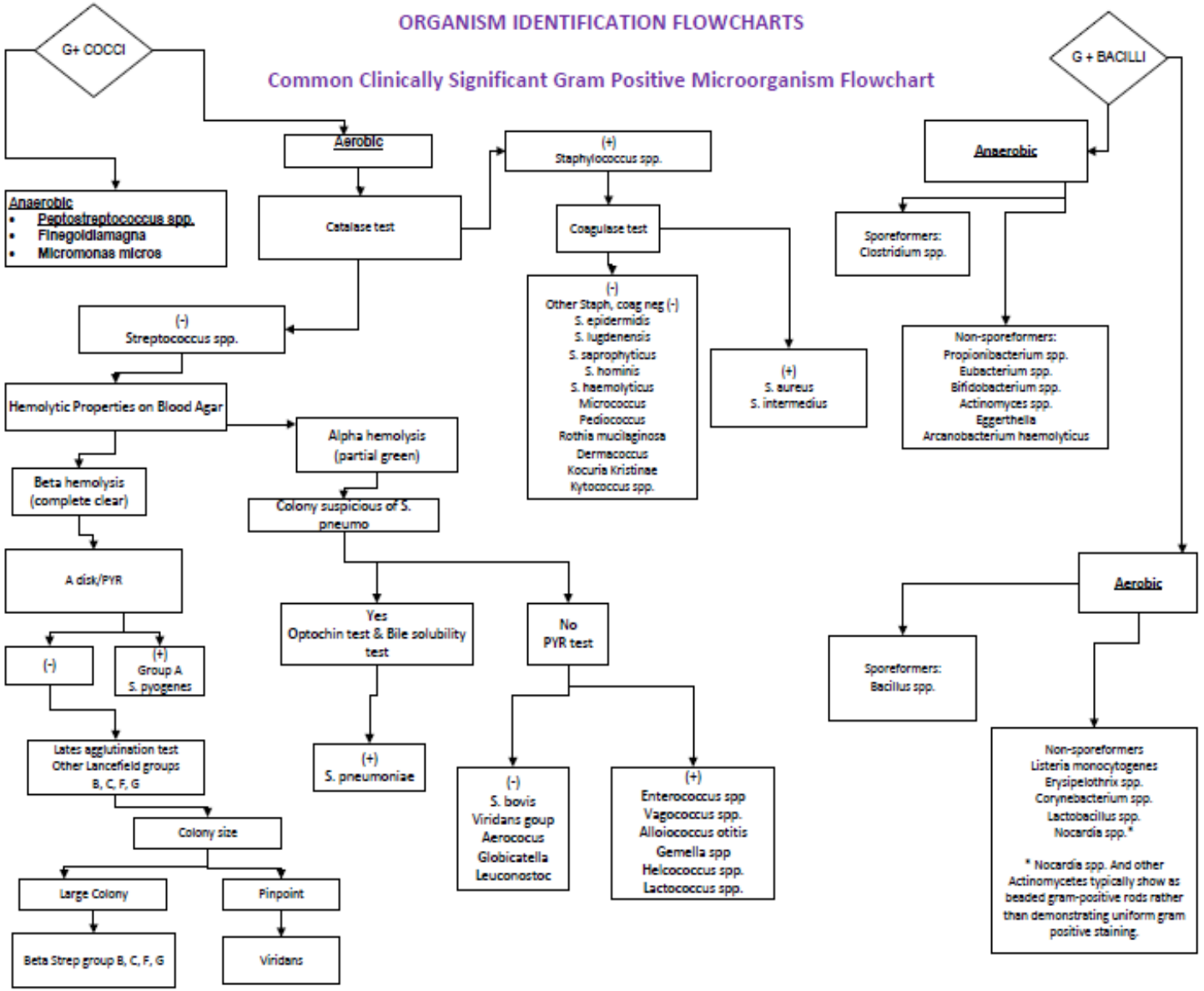
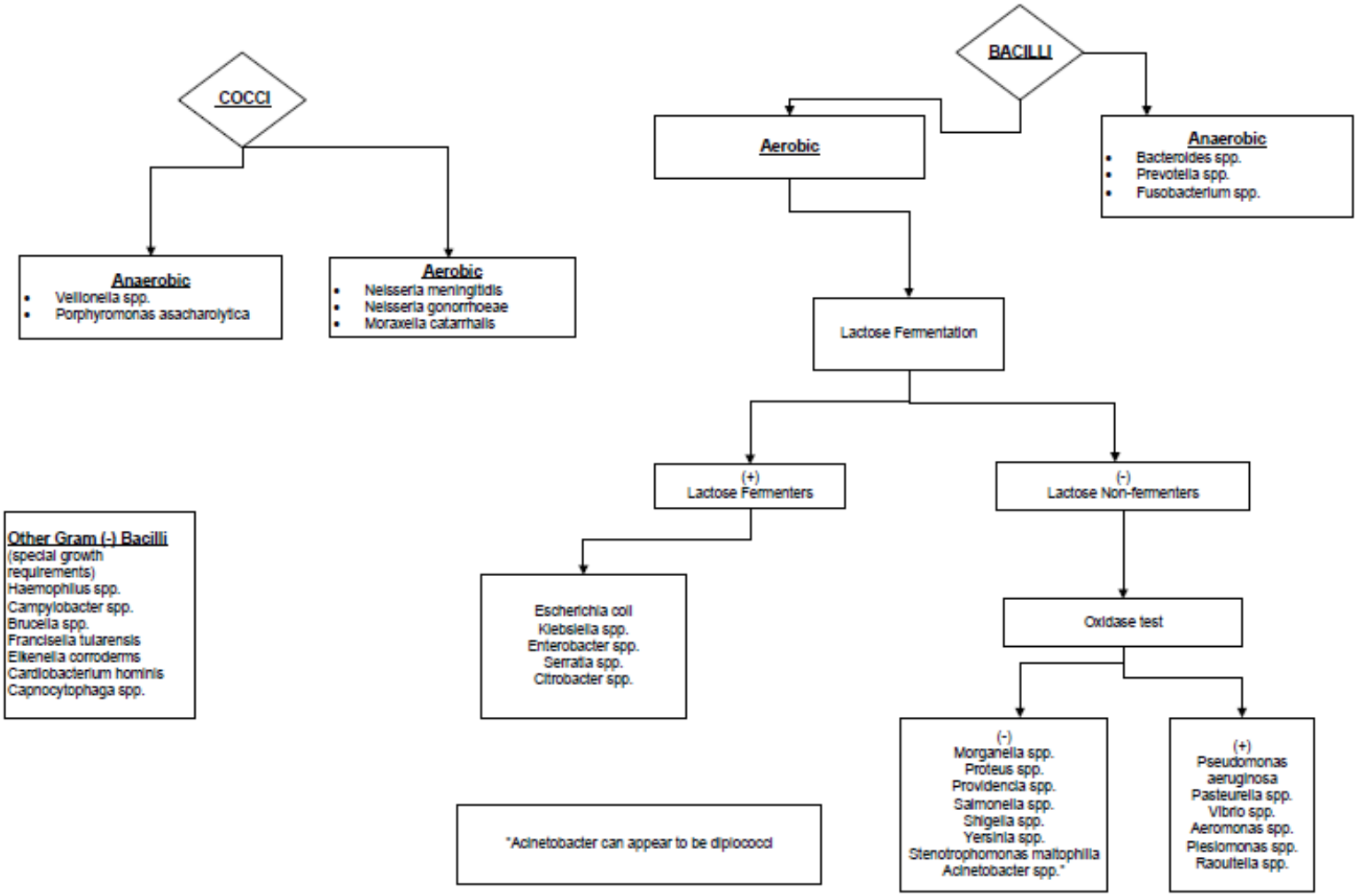
ORGANISM IDENTIFICATION FLOWCHARTS

Common Clinically Significant Gram Positive Microorganism Flowchart



ORGANISM IDENTIFICATION FLOWCHART
Common Clinically Significant Gram Negative Microorganism Flowchart



Key phrases from the Microbiology Laboratory

Phrase	Suggested findings
Gram positive cocci in clusters	*Staphylococcus* species
Gram positive cocci in pairs and chains	*Streptococcus* species or *Enteroccoccus* species
Gram positive cocci in pairs	*Streptococcus pneumoniae*
Small pleomorphic Gram negative coccobacilli	*Haemophilus* species
Pleomorphic Gram positive bacilli	*Corynebacterium* species or *Propionobacterium species*
Branching Gram positive bacilli	*Actinomyces* or *Nocardia* species
Acid fast bacilli	*Mycobacterium* species
Budding yeast or pseudohyphae	yeast
Fungal elements or hyphal elements	mold
Gram negative fusiform bacilli	*Fusobacterium* species

BACTERIOLOGY

Susceptibility Testing

Susceptibility testing is an *in vitro* assay that allows us to detect resistance to antimicrobial agents that may be used to treat an infection. It is important to note however, that clinical outcome may be dependent on various patient specific factors such as immune status or surgical treatment that are not reflected in laboratory tests.

All methods of susceptibility testing are based on diffusion or dilution.

A. Semi-Automated Susceptibility Testing

Semi-automated antimicrobial susceptibility testing is performed using the Vitek 2 system which is based on broth microdilution. This system allows the laboratory to rapidly perform identification and susceptibility testing on most common pathogens (e.g. Staphylococci, Enterobacteriaceae, Enterococci, *Pseudomonas* species, etc…). The antibiotics tested vary based upon the Vitek panel used and the antibiotics that are currently on the LMH formulary. The Vitek panels are chosen and agreed upon by the Infectious Disease specialist, the pharmacy and the microbiology laboratory.

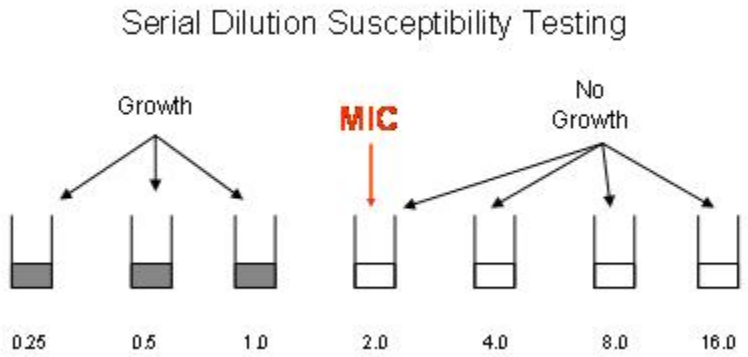
The microbiology laboratory reports antibiotics from most antibiotic classes that are appropriate for the specific organism tested. For example, if the laboratory recovers an isolate from urine, the results from the following antibiotic classes are reported: penicillin, Beta lactam/Beta lactamase combination, cephems, carbapenems, aminoglycosides, fluoroquinolones, nitrofurantoin, and trimethoprim-sulfamethoxazole.

Selective reporting of antibiotics for each organism group is reviewed and approved by the Antimicrobial Stewardship Committee and the medical director of the laboratory annually.

The results obtained from the Vitek system are based on the minimum inhibitory concentration (MIC). The MIC is defined as the lowest concentration of antibiotic that completely inhibits growth of the specific organism being tested.

For example, in figure 1 below, the organism being tested grew in wells containing 0.25, 0.5, and 1.0 ug/ml of antibiotic. The lowest concentration of antibiotic (MIC) that completely inhibits growth was 2.0 ug/ml.

Figure 1:



(http://vads.vetmed.vt.edu/Images/SerialDilutionSusceptibility.jpg)

The MIC is then interpreted (S=susceptibile, I=Intermediate, or R=resistant) using FDA approved guidelines. These guidelines are based on many studies, including clinical, pharmacokinetic/pharmacodynamic, and microbiological studies.

It is important to be aware that, although there are many examples of bacteria and antibiotics for which we have FDA approved guidelines for reporting of automated susceptibility results, there are some bacteria for which FDA approved guidelines do not exist. If susceptibility testing for a specific organism cannot be reported using the automated Vitek method, disc diffusion testing may be performed and results will be reported based on CLSI (Clinical and Laboratory Standards Institute) standards if available.

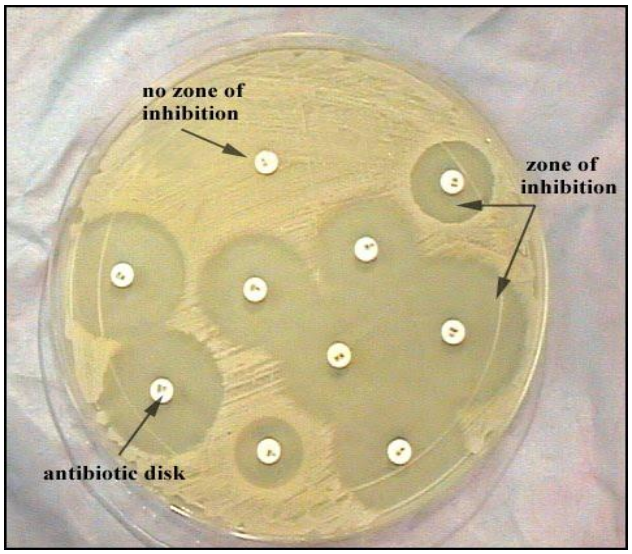
If there are no interpretive standards for automated or disc diffusion testing, the physician may notify the microbiology laboratory (505-6177) and request the isolate be submitted to a reference laboratory for testing.

B. Disk Diffusion

The LMH microbiology laboratory does routinely perform disk diffusion (Kirby Bauer) antimicrobial susceptibility testing for *Pseudomonas aeruginosa* isolates from cystic fibrosis

patients, beta-lactamase positive *Haemophilus* species, and other fastidious organisms. Disk diffusion allows for measurement of the zone of growth inhibition. See figure 2.

Figure 2:



(http://mrsa30day.com/wp-content/uploads/2012/08/Antibiotic-sensitivity.jpg)

The CLSI provides interpretive standards for reporting an organism as S, I, or R based on the zone of inhibition. The main difference between disk diffusion testing and MIC testing is that disk diffusion provides clinicians with qualitative results, whereas MIC testing provides the clinicians quantitative results.

Knowing the MIC can help clinicians incorporate pharmacodynamic/pharmacokinetic principles into the design of the treatment regimen. For instance, if the clinician wants to use ceftriaxone to treat meningitis due to *Streptococcus pneumoniae*, we need to achieve a concentration in the cerebrospinal fluid (CSF) of approximately four times the MIC for about 40% of the dosing interval due to the time-dependent/concentration-independent nature of the drug. Therefore, if the MIC of the *S. pneumoniae* isolate to ceftriaxone is 0.25 ug/ml, we want a concentration of at least 1 ug/ml in the CSF for 40% of the dosing interval.

The size of the zone of inhibition does not give us the MIC, and so in this specific case disk diffusion is not helpful. Also, zone sizes cannot be compared between drugs. Just because drug A has a larger zone size than drug B, it does not mean that drug A will work better. Zone sizes must be correlated back to the CLSI interpretive standards in order to determine susceptibility or resistance.

C. E-test

The LMH laboratory does perform E-test susceptibility testing for daptomycin on all MRSA and VRE isolates from non-respiratory tract sites per the Infectious Disease practitioner. Daptomycin susceptibility testing is available by E-test upon special request by ID or

Pharmacy. Penicillin susceptibility testing is also available by E-test for unusual Strep species.

The E-test is an agar based method that uses a plastic strip with antibiotic concentrations in variable size plastic disks on its underside. When placed on an agar surface pre-inoculated with the bacterial isolate, the diffusing antibiotic creates a concentration gradient in the agar. Decreasing concentrations of antibiotic from the top of the strip to the bottom create an ellipsoid diffusion pattern around the strip. The resultant elliptical zone of inhibition allows the MIC to be read at the point where the zone crosses the E-test strip (figure 3).

Figure 3:

D. Special Susceptibility Testing Issues:

Extended-spectrum Beta-lactamases (ESBL's)

ESBL's are Beta-lactamases that are capable of hydrolyzing expanded-spectrum cephalosporins (ceftriaxone, cefotaxime, and ceftazidime) as well as cefepime and aztreonam. ESBL's can be isolated from many different Enterobacteriaceae species but are most commonly isolated from *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *E. coli*, and *Proteus mirabilis*.

Using the Vitek, isolates that carry ESBL's can initially be intermediate or resistant to one or all of the extended spectrum cephalosporins, cefepime or aztreonam. This is due to the fact that there are many different ESBL's with different substrate specificities. The Vitek gram negative panel includes an ESBL confirmatory test and all ESBL positive isolates are verified. If a particular isolate is confirmed as resistant or intermediate to any of the extended-spectrum cephalosporins, cefepime or aztreonam, the following statement will be included in the report: "Isolate is an ESBL producing strain resistant to all penicillins, cephalosporins, and aztreonam."

ESBL positive E coli isolates from urinary tract specimens will be tested for fosfomycin susceptibility per the Infectious Disease practioner.

The Nanosphere Gram Negative Blood culture assay can detect the CTX-M beta-lactamase resistance mechanism. CTX-M is a beta-lactamase that has potent activity against cefotaxime. The mechanism of resistance is plasmid-mediated.

Because of the significant public health implications, the spread of CTX-M beta-lactamase producers merits close monitoring.

Carbapenemases:
Carbapenemases are beta-lactamases that are capable of hydrolyzing all beta-lactams, including the carbapenems. Carbapenemases can be isolated from many different Enterobacteriaceae species.

Carbapenemases are particularly dangerous resistance mechanisms, since they can inactivate a wide range of different antibiotics. Enterobacteriaceae isolates that produce carbapenemase have been referred to as "Infection Control Emergencies." Bacteria that produce carbapenemases are often referred to in the news as "superbugs" because infections caused by them are extremely difficult to treat.

For all acute care facilities, CDC and HICPAC recommend an aggressive infection control strategy, including managing all patients with carbapenem resistant Enterobacteriaceae (CRE) using contact precautions.

There are several important mechanisms of carbapenem resistance that increases the risk for dissemination:

1. KPC: *Klebsiella pneumoniae* carbapenemase (KPC) refers to the production of a carbapenemase enzyme, bla_{kpc}. The gene that encodes the bla_{kpc} enzyme is carried on a mobile piece of genetic material (transposon), which can easily be passed from one organism to the other.

2. NDM: New Dehli Metallo-beta-lactamase-1 refers to the production of a carbapenemase referred to as NDM-1 enzyme. The most common bacteria that produce this enzyme are gram negatives such as *E coli* and *Klebsiella pneumoniae,* but the gene for NDM bla_{NDM-1} can spread from one strain of bacteria to another by horizontal gene transfer.

3. IMP: IMP-type carbapenemases are plasmid mediated Class B metallo-beta-lactamases that can be found in both enteric Gram-negative organisms and in *Pseudomonas* and *Acinetobacter* species.

4. VIM (Verona integron-encoded metallo-beta-lactamase): The VIM family of carbapenemases occur mostly in *Pseudomonas aeruginosa* and *P. putica* and vary rarely

in Enterobacteriaceae. The VIM enzymes are integron-associated and hydrolyse all beta-lactams and can evade all beta-lactam inhibitors.

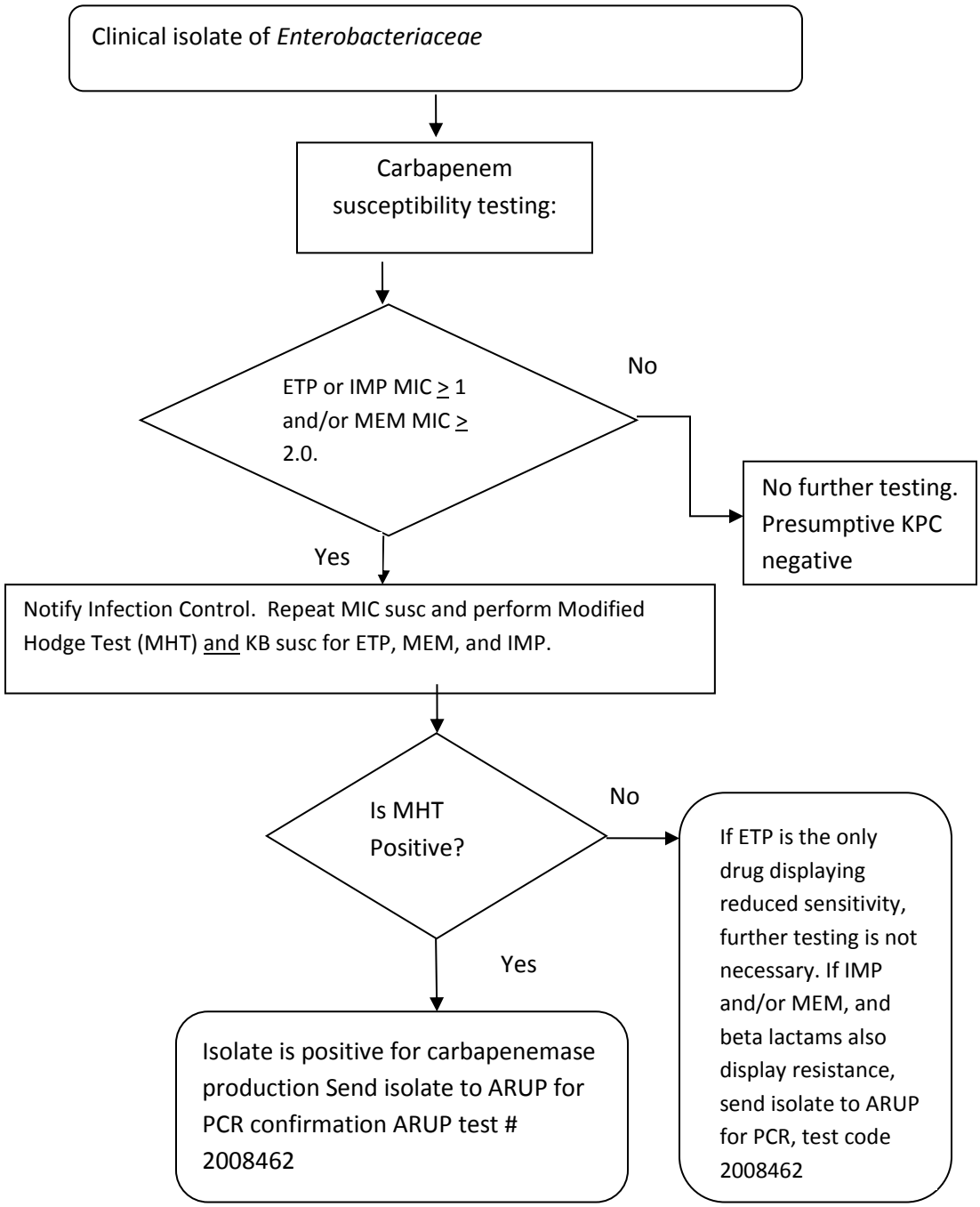
5. OXA (Oxacillinase): The OXA group of beta-lactamases occur mainly in Acinetobacter species.

The Nanosphere Gram Negative Blood Culture assay can detect the following carbapenem resistance mechanisms: KPC, NDM, VIM, OXA, and IMP. Infectious disease consultation is suggested when one of these resistance mechanisms is detected.

If the Vitek susceptibility profile suggests the presence of a carbapenemase producing organism, the microbiology department will repeat testing and will perform a Modified Hodge test on the isolate. The following flowchart was developed for testing based on CDC recommendations.

It is important to note that if an isolate is suspected to be a carbapenem resistant Enterobacteriaceae (CRE), the Infectious Disease specialist and the Infection Preventionist will be notified immediately to ensure the patient is placed in isolation.

Practical Testing Scheme to Detect KPC and NDM-Producing *Enterobacteriaceae* (CRE-Carbapenem Resistant Enterobacteriaceae)

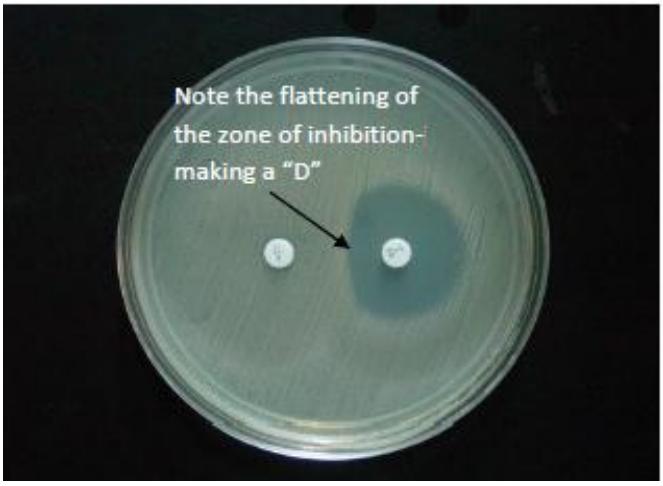


Inducible clindamycin-resistance in *Staphylococcus* and *Streptococcus* species:
Erythromycin resistance within staphylococci is typically mediated through two distinct mechanisms. The first mechanism entails protection of the ribosome from erythromycin and clindamycin through methylation (referred to as MLS_B resistance). This mechanism may be constitutive (conferring resistance to both erythromycin and clindamycin) or inducible (conferring resistance only to erythromycin). Published clinical reports have demonstrated that *S. aureus* isolates carrying an inducible MLS_B resistance gene should be considered resistant to clindamycin even if the *in vitro* result considers the isolate susceptible to clindamycin. The second resistance mechanism is conferred through efflux of erythromycin out of the cell through specific pumps (encoded by the msrA gene). Staphylococcal isolates carrying the MsrA efflux pump are resistant only to erythromycin and not clindamycin.

The Vitek performs an inducible clindamycin resistance (ICR) test (otherwise known as D-test) automatically on *Staph* species, group A Beta *Strep* and group B Beta *Strep*. If the test is positive for ICR, the clindamycin result is not reported and a comment is attached to the report "isolate presumed resistant to clindamycin by ICR testing."

Isolates of *Streptococcus pneumoniae,* and other Beta *Streptococcus* species (as specified by CLSI) may require a manual D-test performed (Figure 4). If the D-test is positive the clindamycin result is not reported and a comment is attached to the report "isolate presumed resistant to clindamycin by ICR testing."

Figure 4
(positive D-test by manual method):



Inducible Methicillin Resistance in Staph aureus:

Methicillin resistance in *S. aureus* is generally due to the presence of the *mecA* gene located on the staphylococcal cassette chromosome *mec*(SCC*mec*). The *mecA* gene codes for production of an altered penicillin binding protein PBP2', also referred to as PBP2a. PBP2' has a low binding affinity for beta-lactam antibiotics. Because oxacillin and other beta-lactams cannot bind to the altered PBP2' site, these antibiotics are ineffective. The 'gold standard' for the detection of MRSA is molecular methodology using either polymerase chain reactions (PCR) or nucleic acid amplification. Molecular methods for detection of genes such as *mecA* that code for resistance are being used in laboratories with increasing frequency. However, routine susceptibility testing by microdilution or disk diffusion is still the method of choice for resistance determination in most laboratories.

Until recently, our laboratory used microdilution and PBP2' latex methods to detect MRSA. In January 2012, the Cepheid SSTI MRSA/MSSA cartridge for use on the GeneXpert platform was added to the laboratory's test menu. In addition to a routine wound culture, we began to offer a special site culture with PCR for MRSA/MSSA. PCR results are available in just over one hour from the time of specimen receipt in the laboratory. PCR testing performed on these specimens is followed up with routine culture and susceptibility testing.

Our laboratory has previously identified *S aureus* isolates from outpatient wound specimens that were positive for the *mec*A gene by PCR that were found to be sensitive to oxacillin by follow-up routine susceptibility testing. Upon further investigation, these isolates were found to demonstrate resistance in vitro, after exposure to a beta-lactam (cefoxitin) antibiotic. In other words, the *S aureus* isolates demonstrated "inducible methicillin resistance."

The prevalence of this inducible methicillin resistant *S aureus* strain (Ridom spa type T175) has been found to be low however susceptibility testing alone can miss these strains. It is important to be aware that this strain has historically been found in our community. Also, it is important to note that if an inducible MRSA isolate were isolated from a serious infection, such as sepsis, and the infection were treated with first-generation cephalosporins or semi-synthetic penicillin, the patient may fail therapy.

INTRINSIC RESISTANCE TABLES

Intrinsic resistance is the innate ability of a bacterial species to resist activity of a particular antimicrobial agent through its inherent structural or functional characteristics. Such natural resistance can be due to: lack of affinity of the drug for the bacterial target, inaccessibility of the drug into the bacterial cell, extrusion of the drug by chromosomally encoded active exporters, or innate production of enzymes that inactivate the drug.

Below are lists of organisms with their respective intrinsic antimicrobial resistance.

Enterococcus species	Antimicrobial agents								
Organisms	Cephalosporins	Vancomycin	Teicoplanin	Aminoglycosides	Clindamycin	Quinupristin-dalfopristin	Trimethoprim	Trimethoprim/Sulfamethoxazole	Fusidic Acid
Enterococcus faecalis	R*			R*	R*	R	R	R*	R
Enterococcus faecium	R*			R*	R*		R	R*	R
Enterococcus gallinarum/ Enterococcus casseliflavus	R*	R		R*	R*	R	R	R*	R

*Warning: For *Enterococcus* spp., cephalosporins, aminoglycosides (except for high level resistance screening), clindamycin, and trimethoprim-sulfamethoxazole may appear active in vitro, but are not effective clinically.

Note: Gram-positive bacteria are also intrinsically resistant to aztreonam, polymyxin B/colistin and naladixic acid.

Staphylococci	Antimicrobial Agents		
Organisms	Novobiocin	Fosfomycin	Fusidic Acid
S. aureus	There is no intrinsic resistance in these species.		
S. lugdenensis			
S. epidermidis			
S. haemolyticus			
S. saprophyticus	R	R	R
S. capitis		R	
S. cohnii	R		
S. xylosus	R		

Notes:

1. Gram positive bacteria are also intrinsically resistant to aztreonam, polymyxin B/colistin and naladixic acid.
2. MRSA and oxacillin resistant coagulase negative staphylococci are considered resistant to other beta-lactam agents, (penicillins, beta-lactam/beta-lactamase inhibitor combinations, cephems with the exception of ceftaroline), and carbapenems.

Enterobacteriaceae	**Antimicrobial Agent**											
Organisms	Ampicillin	Amoxicillin-clavulanic acid	Ampicillin-sulbactam	Piperacillin	Ticarcillin	Cephalosporin I: Cefazolin, Cephalothin	Cephamycins: Cefoxitin, Cefotetan	Cephalosporin II: Cefuroxime	Imipenem	Tetracyclines	Nitrofurantoin	Polymyxin B/Colistin
Citrobacter freundii	R	R	R			R	R	R				
Citrobacter koseri	R			R	R							
Enterobacter aerogenes	R	R	R			R	R	R				
Enterobacter cloacae	R	R	R			R	R	R				
Escherichia coli	There is no intrinsic resistance to beta-lactams in this organism											
Escherichia hermannii	R				R							
Hafnia alvei	R	R	R			R	R					
Klebsiella pneumoniae	R				R							
Morganella morganii	R	R				R		R	*	R	R	R
Proteus mirabilis	No intrinsic resistance to penicillins and cephalosporins								*	R	R	R
Proteus penneri	R					R		R	*	R	R	R
Proteus vulgaris	R					R		R	*	R	R	R
Providencia rettgeri	R	R				R			*	R	R	R
Providencia stuartii	R	R				R				R	R	R
Salmonella* and *Shigella spp	No intrinsic resistance to beta-lactams in these organisms 1ST AND 2ND generation cephalosporins may appear active in vitro, but are not effective clinically.											
Serratia marcescens	R	R	R			R	R	R			R	R
Yersinia enterocolitica	R	R			R	R						

Note: Cephalosporins III, cefepime, aztreonam, ticarcillin-clavulanate, piperacillin-tazobactam, and the carbapenems are not listed, because there is no intrinsic resistance in Enterobacteiaceae.

Enterobacteriaceae are also intrinsically resistant to clindamycin, daptomycin, glycopeptides, (vancomycin), linezolid, macrolides (erythromycin, clarithromycin, azithromycin), quinupristin-dalfopristin, and rifampin.

Non-Enterobacteriaceae	Antimicrobial Agents																				
Organisms	Piperacillin	Ticarcillin	Ampicillin-Sublactam	Amoxicillin-clavulanic	Piperacillin-tazobactam	Ticarcillin-Clavulanate	Cefotaxime	Ceftriaxone	Ceftazidime	Cefepime	Aztreonam	Imipenem	Meropenem	Ertapemem	Polymyxin B/Colistin	Aminoglycosides	Tetracyclines	Ciprofloxacin	Trimethoprim	Trimethoprim/Sulfa	Chloramphenicol	Fosfomycin
Acinetobacter baumannii/ A. calcoaceticus complex			*	R							R			R					R		R	R
Burkholderia cepacia complex	R	R	R	R	R		R	R		R	R	R		R	R	R			R			R
Pseudomonas aeruginosa			R	R			R	R						R			R		R	R	R	R
Steno. maltophilia	R	R	R	R	R		R	R			R	R	R	R		R	#		R			R

1. **Acinetobacter baumannii/calcoaceticus* may appear to be susceptible to ampicillin-sulbactam due to the activity of sulbactam with this species.
2. # *Stenotrophomonas maltophilia* is intrinsically resistant to tetracycline but not to doxycycline or minocycline.
3. Note: Nonfermentative gram-negtive bacteria are also intrinsically resistant to cephalosporin I (cephalothin, cefazolin), cephalosporin II (cefuroxime), cephamycins (cefoxitin, cefotetan), clindamycin, daptomycin, fusidic acid, glycopeptides (vancomycin, teicoplanin), linezolid, macrolides (erythromycin, azithromycin, clarithromycin), penicillin, quinupristin-dalfopristin, and rifampin.

Other organisms:

Organisms	Natural Resistance Against
Anaerobic bacteria	Aminoglycosides
Aerobic bacteria	Metronidazole
Lactobacilli and *Leuconostoc*	Vancomycin
Aerococcus urinae	Sulfonamides and Netilmicin
Cardiobacterium hominis	Clindamycin

CLSI Cumulative Antimicrobial Susceptibility for Bacteroides fragilis Group Organisms																		
Anaerobic Organisms	**Ampicillin-Sublactam**		**Piperacillin-Tazobactam**		**Cefoxitin**		**Ertapenem**		**Imipenem**		**Meropenem**		**Clindamycin**		**Moxifloxacin**		**Metronidazole**	
Percent Susceptible (%S) and Percent Resistant (%R)	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R
B.fragilis	90	3	98	1	87	3	97	2	98	1	96	1	72	23	65	26	96	2
B.thetaiotaomicron	80	4	79	8	48	8	98	1	99	1	98	1	32	55	47	34	100	0
B.ovatus	88	1	95	4	58	9	95	1	100	0	98	0	43	46	32	40	99	0
B.vulgatus	70	5	97	2	82	7	99	1	100	0	98	1	47	52	20	76	100	0
B.uniformis	88	4	95	2	60	9	100	0	100	0	99	0	44	40	27	53	99	0
B.eggerthii	93	0	89	11	34	21	100	0			100	0	29	63	25	38	100	0
Parabacteroides distasonis	66	20	56	30	42	15	97	2	97	0	97	2	25	57	69	27	100	0
B.frag group Not B.frag	78	8	81	11	53	10	98	1	99	0	98	1	35	53	45	40	100	0
B.frag group (all above species)	82	6	87	7	65	7	98	1	99	1	98	1	48	42	51	36	98	1

1. Data was provided by CLSI and generated from 4 referral laboratories: Tufts, Boston MA; Loyola, Maywood IL; RM Alden Research Lab, Culver City, CA; International Health Management Associates, Inc., Schaumburg, IL. (2010-2012)
2. Testing was performed by agar dilution.
3. Resistance to metronidaxole occurs infrequently.
4. Intermediate category is not shown, but can be derived by subtraction of %S and %R from %100.

CLSI Cumulative Antimicrobial Susceptibility for Anaerobic organisms other than Bacteroides fragilis Group Organisms																
Anaerobic Organisms	**Ampicillin-Sublactam**		**Piperacillin-Tazobactam**		**Cefoxitin**		**Ertapenem**		**Imipenem**		**Clindamycin**		**Moxifloxacin**		**Metronidazole**	
Percent Susceptible (%S) and Percent Resistant (%R)	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R	%S	%R
Prevotella spp.	99	0	100	0	97	1	100	0	100	0	72	26	73	24	97	0
Fusobac-terium nucleatum-necrophorum	**100**	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0
Anaerobic Gram positive cocci	88	9	99	0	94	3	83	9	98	1	79	16	63	20	96	3
Veillonella spp.	90	6	84	16	97	0	85	8	97	0	66	34	81	12	97	0
P.acnes	100	0	100	0	100	0	100	0	100	0	91	9	93	3	9	91
Clostridium perfringens	100	0	100	0	100	0	100	0	100	0	96	0	99	1	100	0
C.difficile	100	0	99	1	3	97			93	0	38	48	94	6	100	0
Other Clostridium spp	100	0	98	2	70	17	100	0	99	0	66	21	74	20	98	1

1. Data was provided by CLSI and generated from 4 referral laboratories: Tufts, Boston MA; Loyola, Matwood IL; RM Alden Research Lab, Culver City, CA; International Health Management Associates, Inc., Schaumburg, IL. (2010-2012)
2. Testing was performed by agar dilution.
3. Intermediate category is not shown, but can be derived by subtraction of %S and %R from %100.

Development of Resistance and Testing of Repeat Isolates: Isolates that are initially susceptible may become intermediate or resistant after initiation of therapy. Therefore, subsequent isolates of the same species from a similar body site should be tested in order to detect resistance that may have developed. This can occur within as little as three to four days and has been noted most frequently in *Enterobacter, Citrobacter*, and *Serratia* spp. with third-generation cephalosporins; in *P. aeruginosa* with all

antimicrobial agents, and staphylococci with quinolones. For *S. aureus*, vancomycin-susceptible isolates may become vancomycin intermediate during the course of prolonged therapy.

In certain circumstances, testing of subsequent isolates to detect resistance that may have developed might be warranted earlier that within three to four days. The decision to do so requires knowledge of the specific situation and the severity of the patient's condition.

Interpretation of Microbiology Reports

Semi-quantitative Terminology (rare/few/moderate/many):

The amount of each type of organism seen is quantified when reading gram stains using the following interpretive criteria:

Description	No. per oil immersion field (×1000)	
	Cells	Bacteria
Rare	<1	<1
Few	1–5	2–10
Moderate	6–10	11–50
Many	>10	>50

Of note, when a report says, "rare gram negative bacilli" it does not mean rare as in unusual, it means rare as in very few.

Contaminant vs. Pathogen:

BLOOD

Normally Sterile

PATHOGENS

- Any organism isolated

LIKELY CONTAMINANTS

- Coagulase negative staphylococci
- Alpha-hemolytic streptococci
- *Bacillus* spp.
- *Corynebacterium* spp. (except *C. jeikeium*)
- *Propionibacterium acnes*

TISSUE AND BODY FLUIDS

Normally Sterile

PATHOGENS-Any organism isolated; use judgment to evaluate the possibility of normal flora being present in relation to the source of specimen.

EYE/EAR

NORMAL FLORA:

- coagulase negative Staphylococci
- Non-hemolytic streptococci
- Alpha-hemolytic streptococci
- Diphtheroids

SKIN

NORMAL FLORA:

- coagulase negative staphylococci
- *Propionibacterium acnes*
- Diphtheroids
- Alpha-hemolytic streptococci
- *Bacillus* spp.

GENITAL

PATHOGENS

- *Neisseria gonorrhoeae*
- Beta-hemolytic streptococci (GBS will be held if present for susceptibility testing if needed)
- Predominant growth of Yeast or *S aureus*

URINE

Should be sterile. Cultures with mixed flora will be reported as such if contamination is suspected.

PATHOGENS

- Enterobacteriaceae
- *Enterococcus* spp.
- *Pseudomonas* spp. and other non-fermenters
- Group B *Streptococcus* (*Streptococcus agalactiae*)
- *S. aureus* and *S. saprophyticus*
- Yeast
- *Aerococcus urinae*

STOOL (CULTURES NO LONGER PERFORMED IN-HOUSE):

ENTERIC PATHOGEN TESTING BY PCR/HYBRIDIZATION:

- *Shigella* spp.
- *Salmonella* spp.
- *Campylobacter* group (*C. coli, C. jejuni,* and *C. lari)*
- *Yersinia enterocolitica*
- *Vibrio* group (*V. cholera and V. parahaemolyticus)*
- Shiga-toxin producing strains of *E coli* (both shiga toxin 1 and 2)
- Norovirus (GI and GII)
- Rotavirus A

Note: If cultures for *Aeromonas or Plesiomonas* are needed, specific orders for these organisms will need to be requested and these specimens will be referred to the reference laboratory.

RESPIRATORY TRACT

PATHOGENS:

- Group A *Streptococcus (Streptococcus pyogenes*)

- Group C *Streptococcus* (large colony)
- Group G *Streptococcus* (large colony)
- *Arcanobacterium haemolyticum*
- *Streptococcus constellatus subsp. pharyngis*
- *Streptococcus pneumoniae*
- *Haemophilus influenzae*
- *Moraxella catarrhalis* (predominant)
- *Enterobacteriaceae* (lower respiratory tract)
- *Pseudomonas* spp. and other non-fermenters
- *Burkholderia cepacia*
- Yeast (predominant)
- *S. aureus* (predominant)

Specimen Requirements

Specimen requirements can be found by going to the on-line LMH Lab Test Directory (link as follows): http://www.testmenu.com/lmh

Timing of Reports

Preliminary/Final Reports:
Cultures are examined each day and preliminary reports are generated on a daily basis that include any information or presumptive identification of organisms isolated that would be helpful to the physician. When the culture is completed, a final report is released.

Gram Stain:

Surgical specimens, sterile body fluids and bronch washings and brushings-within 1 hour of receipt in lab

Organism identification:

The organism will be identified within 24 hours of isolation of an organism unless it is an unusual or fastidious organism and/or requires further work-up to confirm.

Susceptibility results:

The susceptibility results will be reported within 24-48 hours of isolation of an organism unless it is an unusual or fastidious organism and/or requires further work-up to confirm identification.

Antibiogram:

The hospital-wide antibiogram can be found on the intranet by selecting the physicians tab directly above the current inpatient census. Select "Antibiogram." It is updated every 6 months and approved by the antibiotic stewardship committee.

Urinalysis and Urine Culture

Indicators of Infection from a Urinalysis:

- Positive leukocyte esterase

- Positive nitrite
- >5 WBC's/hpf

Urine Culture:
A urine culture must ALWAYS be interpreted in the context of a urinalysis and patient symptoms. Ideally, a urine culture would not be performed unless a urinalysis indicated a possible infection. Typically, catheterized patients can become colonized within 48 hours of catheterization. The only patient populations for which it is recommended to screen for and treat asymptomatic bacteriuria are pregnant women and patients scheduled for genitourinary surgical procedure.

Urine cultures are held for 2 days before finalizing as "No Growth."

Guidelines for the Prevention of Perinatal Group B Streptococcal (GBS) Disease published in Nov. 2010 note that the presence of group B Streptococcus in amounts of $\geq$ 10,000 CFU/ml during any trimester is considered indicative of heavy maternal colonization of GBS in the vaginal flora. (i.e. Maternal GBS bacteriuria at any point during pregnancy is a recognized risk factor for early-onset GBS disease and therefore has been included as an indication for intrapartum antibiotic prophylaxis.)

If GBS is present as the predominant organism, susceptibility will be performed and reported. If susceptibility testing is not performed and the patient is female, the organism will be held for 2 weeks and the following comment is attached to the report: "Presence of group B Strep in urine samples of pregnant individuals during any trimester is indicative of heavy maternal GBS colonization if the patient is pregnant and penicillin allergic, notify the laboratory if susceptibility testing is required. Disregard if susceptibility testing was performed."

Stool Testing

Stool for WBC's: The presence of fecal leukocytes suggests inflammation of the bowel. This should lead the physician to evaluate for the cause of inflammation and consider selective cultures for the most common invasive pathogens such as: *Campylobacter* spp., *Salmonella* spp., *Shigella* spp., and enterohemorrhagic *E coli* 0157:H7.

Enteric pathogen (EP) testing: Stool cultures (in-house) were discontinued in July 2015. Testing of liquid and soft stool specimens is now performed on the Verigene Nanosphere system. This assay utilizes amplification (PCR) and hybridization to qualitatively detect and identify common gastrointestinal pathogens.

The EP assay detects and identifies the following enteric bacteria/toxins and viruses: *Campylobacter group (C. coli, C. jejuni, and C. lari), Salmonella* species, *Shigella* species, *Vibrio* group (*V. cholera* and *V. parahaemolyticus), Yersinia enterocolitica,* Shiga toxins 1 and 2 (STEC), Norovirus and Rotavirus. If the sample is positive for Vibrio, Salmonella, Shigella or STEC, the specimen will be sent to KDHE for further identification.

Note: This assay is FDA-approved for testing of liquid or soft stools. Testing of formed stools is not indicated.

If *Plesiomonas shigelloides or Aeromonas* spp. are suspected, separate orders are required for referral to the reference laboratory.

Note: It is inappropriate to order enteric pathogens testing on patients who have been hospitalized for more than 3 days and then develop diarrhea. In these situations, studies have shown that the most common pathogen is *C.difficile* and PCR testing should be ordered.

Stool should be tested for *Clostridium difficile* on patients over 6 months of age with clinically significant diarrhea and a history of antibiotic exposure. Current College of American Pathologists (CAP) guidelines indicate that a provider should consider *C. difficile* testing as an alternative to routine microbiologic studies for inpatients over 6 months of age who have test requests for routine enteric pathogens.

Additionally, CAP clinical guidelines indicate that no more than 2 stool specimens/patient should be accepted without prior consultation with the provider who can explain the limited yield provided by additional specimens.

***Clostridium difficile* testing by PCR:**

The Cepheid Gene XPert C diff/epi assay is the test currently used for diagnosing *C. difficile* infection (CDI) at LMH. This assay is a qualitative *in vitro* diagnostic test for rapid detection of toxin B gene sequences and for the presumptive identification of 027/NAP1/BI strains (epidemic, "epi"), of toxigenic *Clostridium difficile* from unformed (liquid or soft) stool specimens collected from patients suspected of having CDI.

The test utilizes automated real-time polymerase chain reaction (PCR) to detect toxin gene sequences associated with toxin producing *C. difficile*. The assay is intended as an aid in the diagnosis of CDI.

Detection of 027/NAP1/B1 strains of *C. difficile* by the assay is presumptive and is solely for epidemiological purposes and is not intended to guide or monitor treatment for CDI. 027/NAP1/B1 strains of *C. difficile* have been referred to as "hypervirulent." These strains exhibit increased toxin production and are thought to produce more spores leading to enhanced persistence in the environment.

Testing will not be performed on formed stool (stool that does not take the shape of the container) unless a rare case of ileus is suspected. In cases of suspected ileus, a formed stool may be tested by special request of the physician.

The *C. difficile* assay should not be used to assess response to therapy. Patients can continue to test positive after treatment.

Blood Cultures

A minimum of two sets (four bottles; one set = one aerobic bottle + one anaerobic bottle) should usually be obtained. The suggested volume of blood per bottle for adults is 10 ml.

Ordering one set may lead to confusion if the culture is positive for an organism that is commonly a contaminant. For example, if one set is ordered and is positive for coagulase-negative staphylococci (CoNS), a common contaminant, it is difficult to determine if this represents contamination or infection.

However, if two sets are ordered, and only one is positive for CoNS, this most likely represents contamination.

Please specify the desired sites of the blood draw (e.g., one from line, one peripherally). Ideally, blood cultures should be drawn before the first dose of antibiotics, but antibiotics should not be withheld because of a delay in getting cultures drawn. Although it is common practice to wait 30-60 minutes between blood cultures, there is little data to support this practice, and we do not recommend it.

If a vascular catheter is thought to be a potential site of infection, blood should be drawn from the catheter and the periphery. Site and time of phlebotomy should be noted. The differential time to positivity can help in assessing whether the catheter is the likely source.

Differential Time to Positivity (DTP)

a. A positive line culture result is obtained at least 2 hours earlier than a positive peripheral blood culture result.

b. Typically, the diagnosis of a line-associated infection can be made according to the following criteria: presence of an intravascular device, at least one positive blood culture obtained from a peripheral site, clinical manifestations of infection, and no other apparent source for bloodstream infection

Blood Cultures are held for 5 days prior to reporting the culture as final for no growth.

Blood cultures are continuously monitored by the BacTAlert 3D analyzer. If a positive bottle is detected, a gram stain is prepared and the bottle is sub-cultured at that time. The result of the gram stain is called to the physician immediately.

If the Gram stain indicates the presence of a possible staphylococci (Gram positive cocci in clusters), PCR testing is performed on the Gene XPert analyzer for the presence or absence of targets specific for *S aureus* and MRSA.

If the PCR assay detects the presence of *S aureus* but does not detect the presence of the targets specific for MRSA (*mecA* gene and SCC*mec* cassette), the result will be reported as: "positive for *S aureus* by PCR, MRSA negative. " A comment is attached to this result stating: "the *mec*A gene which most often determines methicillin resistance is not present, susceptibility testing to follow." It is important to note that there are rare cases of methicillin resistance due to mechanisms other than the *mec*A gene such as *mec*C and hyper-Beta-lactamase production.

If the Gram stain indicates the presence of possible streptococci (Gram positive cocci in pairs or chains), micro-array testing will be performed on the Verigene analyzer for the presence or absence of targets specific for:

Streptococccus pyogenes (group A Beta *Strep*)

Streptococcus agalactiae (group B Beta *Strep*)

Streptococcus pneumoniae (*Streptococcus mitis* can cross react with *S pneumo* target)

Streptococcus anginosus group

Streptococcus species

Enterococcus faecalis

Enterococcus faecium

Listeria species

The assay can also detect the *vanA* and *vanB* vancomycin resistance mechanisms if *Ec faecalis or Ec faecium* are detected.

If the Gram stain indicates the presence of Gram negative bacilli (rods), micro-array testing will be performed on the Verigene analyzer for the presence or absence of targets specific for:

Acinetobacter species

Citrobacter species

Enterobacter species

E coli

Klebsiella oxytoca

Klebsiella pneumoniae

Proteus species

Pseudomonas aeruginosa

The assay can also detect the CTX-M, KPC, NDM, OXA, IMP and VIM resistance mechanisms if an organism is detected.

Respiratory Cultures/Testing

Lower respiratory tract: Appropriate specimens to identify pathogens causing disease of the lower respiratory tract (tracheitis, bronchitis, pneumonia, lung abscess, and empyema) include expectorated and induced sputum, endotracheal tube aspirations, bronchial brushings, washes, or alveolar lavages collected during bronchoscopy and pleural fluid.

Sputum evaluations are performed on all sputum specimens using the gram stain to assess for quality (lack of contaminating oral respiratory tract flora and epithelial cells). An acceptable specimen generally yields less than 10 squamous epithelial cells per low power field. The presence of 25 or more polymorphonuclear leukocytes per low power field together with few squamous epithelial cells, implies an excellent specimen.

If the specimen is of poor quality, a comment is attached to the gram stain report, “Suggests orophapharyngeal contamination, interpret accordingly.” The number of white blood cells may not always be relevant, because many patients are severely neutropenic and specimens from these patients will not show white blood cells on gram stain examination. If the specimen is from a patient (from either the ED or an inpatient floor) with a diagnosis of pneumonia and the specimen is poor quality, a new specimen may be requested.

Upper respiratory tract: Appropriate specimens to identify pathogens causing upper respiratory tract infections include samples from the nasopharynx, throat, oral ulcerations, and inflammatory material from the nasal sinuses.

Specific pathogens or normal respiratory flora are quantified in the culture report using the terms –many, -moderate, or –few.

All negative rapid strep tests for group A Strep are followed up with culture for group A, C, F, and G Beta hemolytic *Streptococcus*, *Arcanobacterium haemolyticum* and *Streptococcus constellatus ssp. pharyngis*.

***Legionella* and *S pneumo* antigen testing:** It is important to note that as an alternative to culture for *Legionella*, the laboratory offers a highly sensitive rapid EIA for the detection of *L. pneumophilia* antigen in the urine of patients suspected of having legionellosis. The laboratory offers a similar rapid EIA test for the detection of *S. pneumoniae* antigen in the urine of patients suspected of having pneumococcal pneumonia or sepsis. Note: A negative result does not rule out the possibility of infection but indicates that the antigen may be below the limits of detection for this assay.

Bordetella panel: The laboratory offers in-house qualitative testing using PCR for the detection of *Bordetella pertussis, Bordetella parapertussis/bronchiseptica, and Bordetella holmesii* from nasopharyngeal swabs in Universal Transport Media (UTM). Other specimen types have not been validated.

Results are reported as Detected or Not Detected. A specimen yielding a negative result may contain respiratory viruses or bacteria other than those included in the assay.

A negative test result does not exclude the possibility of infection because test results may be affected by improper specimen collection, concurrent antibiotic therapy or the number of organisms in the specimen which may be below the sensitivity of the test.

The test takes 2.5 hours to complete. Specimens collected from inpatients and patients in the Emergency Department will be performed stat. Specimens received from clinics will be performed on a routine basis ensuring results in less than 24 hours.

Genital Tract Cultures/Testing

Genital tract cultures are performed in the microbiology laboratory to determine the etiology of various clinical syndromes, including vulvovaginitis, genital ulcers, urethritis, cervicitis, endometritis, salpingitis, and ovarian abscess in females and urethritis, epididymitis, prostatitis, and genital ulcers in males.

Genital tract cultures are held for 3 days before finalizing the report.

Bacterial Vaginosis: The gram stain is the preferred method for detecting bacterial vaginosis (BV). While it is true that *Gardnerella vaginalis* (one of the prevalent organisms in BV) is easily cultured, it can be present in greater than 60% of normal patients. The presence of “clue cells” an indication of BV, can only be determined from a gram stain and culturing the anaerobic bacteria associated with BV is too costly and time-consuming, therefore the culture should not be used for the diagnosis of bacterial vaginosis.

In our laboratory graded criteria for evaluation of the gram stain is used for determining the presence or absence of suspected bacterial vaginosis. One of the following interpretations is attached to the gram stain report: "No Evidence of Bacterial Vaginosis" (Grade 1); "Intermediate for Bacterial Vaginosis" (Grade 2); or "Bacterial Vaginosis Indicated upon Smear Review." If the specimen quality was poor a comment will be attached to the report indicating "Submitted specimen does not have sufficient vaginal material to evaluate for bacterial vaginosis."

GBS screens: Our laboratory offers two separate orders for GBS screens on pregnant females at 35 to 37 weeks of gestation. STREPB is the pneumonic developed at LMH for GBS screening on non-allergic patients. STRPBS is the pneumonic developed at LMH for GBS screening on penicillin-allergic patients to ensure that if the test is positive susceptibility testing will be performed.

Chlamydia/GC testing: The laboratory offers in-house testing using real-time PCR for the detection of *Chlamydia trachomatis* (CT) and *Neisseria gonorrhoeae* (NG) from both endocervical swabs and urine specimens. A specimen adequacy control has been added to this test to detect human cells and DNA which ensures the specimen quality is acceptable.

Results are reported as Detected or Not Detected for each specific organism. An Invalid result can be due to the presence of interfering substances or it can be due to the absence of human cells or DNA.

This test should not be used for the evaluation of suspected sexual abuse or for other medico-legal indications. This assay has not been evaluated in patients less than 14 years of age.

A negative test result does not exclude the possibility of infection because test results may be affected by improper specimen collection, concurrent antibiotic therapy or the number of organisms in the specimen which may be below the sensitivity of the test.

The test takes 90 minutes to complete. Specimens collected from patients in the Emergency Department will be performed stat. Specimens received from clinics will be performed on a routine basis ensuring results in less than 24 hours Monday through Friday.

The sensitivities and specificities of the various specimen types are as follows:

	Endocervical Swabs		**Female Urine**		**Male Urine**	
	CT	**NG**	**CT**	**NG**	**CT**	**NG**
Sensitivity	**96.0%**	**100%**	**98.1%**	**94.4%**	**98.5%**	**98.3%**
Specificity	**99.6%**	**>99.9%**	**99.8%**	**>99.9%**	**99.8%**	**99.9%**

Trichomonas vaginalis (TVPCR):

The laboratory offers in-house testing using real-time PCR for the detection of *Trichomonas vaginalis* (TV) from both endocervical swabs and urine specimens. A specimen adequacy control has been added to this test to detect human cells and DNA which ensures the specimen quality is acceptable.

Results are reported as Detected or Not Detected. An Invalid result can be due to the presence of interfering substances (such as blood or mucous) or it can be due to the absence of human cells or DNA.

This test should not be used for the evaluation of suspected sexual abuse or for other medico-legal indications.

A negative test result does not exclude the possibility of infection because test results may be affected by improper specimen collection, concurrent antibiotic therapy or the number of organisms in the specimen which may be below the sensitivity of the test.

The test takes 70 minutes to complete, however positives may come off as soon as 40 minutes. Specimens collected from patients in the Emergency Department will be performed stat. Specimens received from clinics will be performed on a routine basis ensuring results in less than 24 hours Monday through Friday.

The sensitivities and specificities of the various specimen types are as follows:

	Endocervical Swabs	**Female Urine**
	TV	**TV**
Sensitivity	**98.9%**	**98.4%**
Specificity	**98.9%**	**99.7%**

At the time of go-live in May 2016, FDA-approval for testing male urine was pending. Testing of male urine will be performed upon FDA-approval.

Mycobacteriology

Specimens submitted to the laboratory for acid fast culture will be sent to the Kansas Department of Health and Environment for testing. Our laboratory will perform an acid fast stain and report results within 24 hours of receipt. The state laboratory will perform a culture and fluorescent stain for *Mycobacterium* spp. and will concentrate specimens as necessary.

Specimen requirements:

Sputum: Spontaneously produced sputum is the specimen of choice. A good sputum is 5-10 mls with a minimal amount of oral or nasal secretion. Three specimens (at least one must be a first morning specimen) should be submitted, refrigerated until processed, are desirable. These specimens should be collected at least 8 hours apart. Respiratory Therapy may collect an induced specimen using inhalation treatment or nebulization. See notation regarding Acid Fast Bacilli Culture and Smear with PCR for M-TB complex below.

Urine: Early morning clean-voided specimens are preferred. Specimens should be submitted daily for at least 3 days. Refrigeration prior to processing is necessary. Direct smears are not prepared on urine specimens. Pooled specimens are not desirable because of excessive dilution, higher contamination and difficulty in concentrating.

Tissue and Body Fluids: All body fluids, exudates, and tissue should be submitted in sterile containers. Large amounts are preferable. Small amounts of exudates may require moistening with sterile saline and tissues may be sent in a small amount of sterile saline.

Gastric Lavages: Optimal time for gastric lavage is early in the morning before meals. The objective of gastric lavage is to obtain sputum that may have been swallowed during the night. The specimen should be obtained at least 8 hours after the patient has eaten or taken oral drugs. The procedure should be limited to senile, non-ambulatory patients, children younger than 3 years of age, and patients who fail to produce sputum by aerosol induction. Specimens should be collected as a series of three specimens collected on separate days.

A preliminary report is received from the state within 3-5 days. A final report, if negative, is issued at 8 weeks. Positive interim reports from DNA probes may be available in 3-5 days. Positive culture results will take 2-4 weeks.

The patient's physician is notified immediately if any report is positive for AFB.

The state will NOT perform sensitivities on *M. tuberculosis* isolates. If susceptibility testing is requested for *Mycobacterium* spp. other than *M. tuberculosis*, notify the microbiology lab at 505-6177 so that KDHE can be requested to send the isolate to us so that our laboratory can forward it to the reference laboratory for susceptibility testing.

In July 2016, the microbiology laboratory added a new molecular test on the Cepheid Gene Xpert for the rapid detection of *Mycobacterium tuberculosis* complex (MTB) and rifampin resistance associated mutations of the rpoB gene from both raw induced or expectorated sputum specimens. This MTB/RIF assay does not differentiate between the species of MTB-complex (*M. tuberculosis, M. bovis, M. africanum, M. canettii, M. microti, M. caprae, M. pinnipedi, M. mungi,* and *M. orygis*).

This assay is intended for use with specimens from patients for whom there is clinical suspicion of TB and who have received no more than 3 days of therapy of anti-tuberculosis therapy. This test is intended as an aid in the diagnosis of pulmonary tuberculosis when used in conjunction with clinical and other laboratory findings.

A result of "MTB not detected" from two sputum specimens is highly predictive of the absence of *M. tuberculosis* complex and can be used as an aid in the decision of whether continued airborne infection isolation (AII) is warranted in patients with suspected pulmonary tuberculosis.

The test name is "AFB by PCR with culture (AFBPCR). The test takes 2.5 hours to complete. Testing will be performed on the day shift only. This assay is not FDA approved for bronchial washings (BW's) or broncho-alveolar lavage (BAL) specimens.

A negative test result does not exclude the possibility of isolating MTB-complex from the sputum sample.

Virology

Virus detection- There are four general ways in which viral infections can be detected: culture, direct viral antigen detection, serology, or nucleic acid detection.

Culture: Specimens for culture will be sent to the reference laboratory. The site of collection must be noted for the reference laboratory to perform testing. The specimen should preferably be submitted in

viral transport media (a sterile container is acceptable) and delivered to the laboratory as soon as possible.

CSF for Enterovirus: Enterovirus testing on CSF is available in-house on the Cepheid Gene XPert analyzer. The XPert EV assay is a reverse transcription polymerase chain reaction (RT-PCR) using the Gene XPert Dx System for the presumptive qualitative detection of Enterovirus (EV) RNA in cerebrospinal fluid (CSF) specimens from individuals with signs and symptoms of meningitis. This test, in conjunction with other laboratory results and clinical information, may be used as an aid in the laboratory diagnosis of enterovirus infection in patients with a clinical suspicion of meningitis or meningoencephalitis.

Expected turnaround time for the enterovirus assay is 3.5 hours form time of receipt of the CSF in the laboratory.

Influenza A/B and RSV by PCR: PCR testing for Influenza A, Influenza B, and RSV (subtypes A and B) are available in-house. The specimen requirement is a nasopharyngeal swab in viral media (UTM kit) or a nasopharyngeal aspirate. The specimen should be refrigerated if there is more than a 24 hour delay in delivery to the laboratory. The assay takes 1.5 hours to perform. Testing of inpatients for Influenza/RSV must be ordered by PCR. Note: Rapid testing for influenza A/B and RSV is available for outpatients, however, PCR testing can be ordered on these patients if specified by the physician.

Direct Respiratory Viral Antigen Detection: Rapid tests are available in the laboratory for Respiratory Syncytial Virus (RSV) and Influenza A/B. The specimen of choice is a nasopharyngeal swab in viral media (UTM kit).

Respiratory Pathogen Panel: The laboratory offers in-house qualitative testing using PCR for the detection of: Influenza A, Influenza A (subtype H1), Influenza A (subtype H3), Influenza B, Parainfluenza 1, Parainfluenza 2, Parainfluenza 3, Parainfluenza 4, RSV A, RSV B, Rhinovirus, Adenovirus, human Metapneumovirus, *Bordetella pertussis, Bordetella parapertussis/bronchiseptica, and Bordetella holmesii* from nasopharyngeal swabs in Universal Transport Media (UTM). Other specimen types have not been validated.

Results are reported as Detected or Not Detected. A specimen yielding a negative result may contain respiratory viruses or bacteria other than those included in the assay. A negative test result does not exclude the possibility of infection because test results may be affected by improper specimen collection, concurrent antibiotic therapy or the number of organisms in the specimen which may be below the sensitivity of the test.

The test takes 2.5 hours to complete. Specimens collected from inpatients and patients in the Emergency Department will be performed stat. Specimens received from clinics will be performed on a routine basis ensuring results in less than 24 hours.

Rotavirus Detection: Rotavirus is a major cause of acute gastroenteritis, especially in children 6 to 24 months in age. In addition, rotavirus infections can produce severe illness as well as asymptomatic infection in adults. The incubation period of rotavirus infection is usually one to three days, followed by gastroenteritis with an average duration of five to eight days. Virus titers in stool reach a maximum shortly after the onset of illness, then decline. Due to inadequacies in existing culture methods, human rotavirus is not routinely isolated from rotavirus-containing specimens.

The Enteric Pathogens (EP) molecular assay detects Rotavirus A in liquid or soft stool. The specimen requirement is a stool specimen in a clean container or in Cary Blair preservative.

Norovirus Detection: Noroviruses are highly contagious and cause on average 19-21 million cases of acute gastroenteritis each year ranking norovirus in the top five pathogens for enteric illnesses.

The Enteric Pathogens (EP) molecular assay detects Norovirus GI and GII in liquid or soft stool. The specimen requirement is a stool specimen in a clean container or in Cary Blair preservative.

Mycology

Specimen Collection: The ideal specimens for fungal isolation are either tissue, sterile body fluid, or blood. If a tissue specimen is to be tested for the presence of fungi, it is important that part of the specimen is sent to the microbiology laboratory **before** the specimen is fixed in formalin for histological examination. Blood to be tested for fungus should be added to a separate blood culture bottle that can be held for 30 days.

Timing of Reports: Moulds may take 3-4 weeks to grow, whereas yeasts grow rather rapidly and can usually be identified within 3-5 days. Specimens will be finalized at 4 weeks.

Susceptibility Testing: Susceptibility testing is performed by the reference laboratory only upon special request. If susceptibility testing is needed, please contact the microbiology laboratory at 505-6177. If susceptibility testing is needed for mould, a list of antifungals for testing must be specified for the reference laboratory to perform testing.

Cryptococcus Antigen Testing in CSF/serum: The laboratory offers a highly sensitive rapid lateral flow assay that can be performed on serum or CSF. This assay is more sensitive than culture, India ink, latex agglutination and enzyme immunoassay (EIA). The assay will detect antigens for *Cryptococcus* species complex (*Cryptococcus neoformans and Cryptococcus gattii*). This test is not meant to be used as a screening test for the general population. It should only be done when clinical evidence suggests the diagnosis of cryptococcal disease.

Parasitology

Ova and Parasites: An O&P test should be ordered on patients presenting with a history of chronic diarrhea (> 10 days). It is **not** appropriate to order an O&P test if the patient develops diarrhea while in the hospital. Due to the low incidence of most parasitic infections in the United States and Kansas, stool specimens for Ova and Parasite are routinely tested only for *Giardia lamblia* and *Cryptosporidium parvum* through an EIA test. However, if the patient has a travel history that includes regions of the world where parasitic infections are endemic, microscopic evaluation for ova and parasites can be ordered. Please contact the microbiology lab if this is the case (505-6177). These specimens will then be submitted to the Kansas Department of Health and Environment laboratory for further testing.

Timing of Reports: A *Giardia/Cryptosporidium* antigen test is available every day of the week and is offered on all shifts.

Malaria Exam: Specimens submitted for malaria exam are tested by both a Rapid immunochromatographic assay in addition to smear exam. Malaria smears are performed in the microbiology laboratory, however, malaria may be found by the hematology department from the differential smear. Thin and thick smears are both examined using the Giemsa stain. All smears positive

for malaria are reviewed and percent of parasitemia is determined by the pathologist. If a previously unknown positive is found, the specimen will be sent to the CDC for further testing.

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LMH Antimicrobial Formulary
July 2015
(Key: $: <$25; $$: $26-$100; $$$: $101-$150; $$$$: >$150)

Antifungals

Azole Antifungals

Fluconazole 200 mg premix (DIFLUCAN)	200 mg	100 mL Bag	$
Fluconazole 400 mg premix (DIFLUCAN)	400 mg	200 mL Bag	$
Fluconazole inj (DIFLUCAN)	100 mg	50 mL SDV	$
Fluconazole susp (DIFLUCAN)	200 mg	5 mL suspension	$
Fluconazole tab (DIFLUCAN)	100 mg	1 tablet	$
Itraconazole (SPORANOX)	100 mg	1 capsule	$
Ketoconazole (NIZORAL)	200 mg	1 tablet	$
Voriconazole (VFEND)	50 mg	1 tablet	$
Voriconazole (VFEND)	200 mg	1 tablet	$$

Echinocandins

Micafungin (MYCAMINE)	50 mg	5 mL injection	$$$
Micafungin (MYCAMINE)	100 mg	5 mL injection	$$$$

Misc Antifungals

Betameth/mupir/miconazole oint(-)			$$
Flucytosine (ANCOBON)	500 mg	1 capsule	$$
Terbinafine (LamISIL)	250 mg	1 tablet	$

Polyenes

Amphotericin B Inj (AMPHOTERICIN B)	50 mg	1 vial injection	$
Amphotericin B LIPOSOMAL(Ambisome)	50 mg	12.5 mL injection	$$$$

Anti-infectives

Amebicides

Paromomycin (PAROMYCIN)	250 mg	1 capsule	$

Aminoglycosides

Amikacin Inj.(AMIKACIN SULFATE)	500 mg	2 mL inj	$

Aentamicin (baby/peds) PF (GENTAMICIN)	20 mg	2 mL inj	$
Gentamicin (GARAMYCIN)	80 mg	2 mL injection	$
Gentamicin (GENTAMICIN)	40 mg	1 mL inj	$
Gentamicin (GENTAMICIN SULFATE, INJECTABLE)	40 mg	1 mL injection	$
Neomycin (NEOMYCIN SULFATE)	500 mg	1 tablet	$
Streptomycin	1 g	1 EA injection	$
Tobramycin Inhalation (TOBI)	300 mg	5 mL Inhaler	$
Tobramycin (NEBCIN)	40 mg	1 mL injection	$
Tobramycin (NEBCIN)	80 mg	2 mL injection	$

Carbapenems

Ertapenem (INVanz)	1,000 mg	1 vial injection	$$
ImiPENem-cilastatin (PRIMAXIN IV)	250 mg	1 vial injection	$
ImiPENem-cilastatin (PRIMAXIN IV)	500 mg	1 vial injection	$$
MEROpenem (MERREM)	500 mg	1 vial injection	$$
MEROpenem (MERREM)	1,000 mg	1 vial injection	$$

Cephalosporins

First generation Cephalosporins

Cefadroxil (DURICEF)	500 mg	1 capsule	$
CeFAZolin duplex bag(ANCEF)	1,000 mg	50 mL duplex bag	$
CeFAZolin premix bag (ANCEF)	1,000 mg	50 mL Bag	$
CeFAZolin vial (ANCEF)	1,000 mg	1 vial inj	$
Cephalexin 200ml susp (KEFLEX)	250 mg	5 mL suspension	$
Cephalexin susp (KEFLEX)	125 mg	5 mL suspension	$
Cephalexin (KEFLEX)	500 mg	1 capsule	$

Second generation Cephalosporins

Cefaclor 187/5ml susp (Ceclor)	187 mg	5 mL suspension	$
Cefaclor susp (CECLOR)	250 mg	5 mL suspension	$
Cefaclor susp (CECLOR)	125 mg	5 mL suspension	$
Cefaclor (CECLOR)	250 mg	1 capsule	$
Cefotetan premix bag (CEFOTAN)	1 g	50 mL Bag	$
Cefotetan premix bag (CEFOTAN)	2 g	50 mL Bag	$
Cefotetan vial (CEFOTAN)	2 g	1 vial injection	$$

CefoTEtan vial(CEFOTAN)	1,000 mg	1 vial injection	$
CefoTEtan vial (CEFOTAN)	2,000 mg	1 vial injection	$$
Cefotetan (CEFOTAN)	1 g	1 vial injection	$
Cefotetan (CEFOTAN)	2 g	50 mL injection	$
CefOXItin duplex (MeFOXin)	2,000 mg	50 mL duplex bag	$
CefOXitin (MeFOXin)	1,000 mg	1 vial inj	$
CefOXitin (MeFOXin)	2,000 mg	1 vial inj	$$
Cefprozil susp (CEFZIL)	125 mg	5 mL suspension	$
Cefprozil (CEFZIL)	500 mg	1 tablet	$
CeFUROxime (CEFTIN)	250 mg	1 tablet	$
CeFUROxime (ZINACEF)	1,500 mg	1 vial injection	$
Third generation cephalosporins			
Cefixime (SUPRAX)	400 mg	1 tablet	$
Cefotaxime (CLAFORAN)	1 g	1 vial injection	$
CefoTAXime (CLAFORAN)	1,000 mg	1 vial inj	$
Cefpodoxime susp (VANTIN)	50 mg	5 mL suspension	$
Cefpodoxime (VANTIN)	200 mg	1 tablet	$
CefTAZidime (FORTAZ)	1,000 mg	1 vial injection	$
CefTRIAXone premix (ROCEPHIN)	1,000 mg	50 mL Bag	$
CefTRIAXone premix (ROCEPHIN)	2,000 mg	50 mL Bag	$
CefTRIAXone vial (ROCEPHIN)	250 mg	1 vial inj	$
CefTRIAXone vial (ROCEPHIN)	500 mg	1 vial injection	$$
CefTRIAXone vial (ROCEPHIN)	1,000 mg	1 vial inj	$$
CefTRIAXone vial (ROCEPHIN)	2,000 mg	1 vial inj	$$$
Ceftriaxone vial (ROCEPHIN)	2,000 mg	1 vial injection	$$$
CefTRIAXone (ROCEPHIN)	1 g	0 injection	$$
CefTRIAXone (ROCEPHIN)	500 mg	1 vial injection	$$

CefTRIAXone (ROCEPHIN)	1,000 mg	1 vial injection	$$
Fourth generation cephalosporins			
CefePIME (MAXIPIME)	1 g	1 vial inj	$
CefePIME (MAXIPIME)	2 g	1 vial inj	$$
Glycylcyclines			
Tigecycline (TYGACIL)	50 mg	1 vial IV Piggyback	$$
Leprostatics			
Dapsone	100 mg	1 tablet	$
Dapsone	25 mg	1 tablet	$
Lincomycin derivatives			
Clindamycin oral (CLEOCIN)	150 mg	1 capsule	$
Clindamycin premix bag (CLEOCIN)	300 mg	50 mL Bag	$
Clindamycin premix bag (CLEOCIN)	600 mg	50 mL Bag	$
Clindamycin premix bag (CLEOCIN)	900 mg	50 mL Bag	$
Clindamycin susp (CLEOCIN PEDIATRIC)	75 mg	5 mL suspension	$
Clindamycin (CLEOCIN PHOSPHATE)	300 mg	2 mL inj	$
Clindamycin (CLEOCIN PHOSPHATE)	600 mg	4 mL injection	$
Clindamycin (CLEOCIN PHOSPHATE)	900 mg	6 mL injection	$
Macrolides			
Azithromycin Inj (ZITHROMAX IV)	500 mg	1 vial inj	$$
Azithromycin (ZITHROMAX)	100 mg	5 mL suspension	$
Azithromycin(ZITHROMAX)	200 mg	5 mL suspension	$
Azithromycin(ZITHROMAX)	250 mg	1 tablet	$
Clarithromycin(BIAXIN)	125 mg	5 mL suspension	$
Clarithromycin(BIAXIN)	250 mg	1 tablet	$
Clarithromycin(BIAXIN)	250 mg	5 mL suspension	$
Clarithromycin(BIAXIN)	500 mg	1 tablet	$
Erythromycin EC (ERYTHROMYCIN BASE)	250 mg	1 cap EC Capsule	$
Erythromycin EC Tablet (ERY-TAB)	500 mg	1 tab EC Tablet	$
Erythromycin susp (Eryped 200)	200 mg	5 mL Susp	$

Erythromycin susp (ERYTHROMYCIN)	200 mg	5 mL Susp	$
Erythromycin (-)	500 mg	1 vial REC Injection	$
Erythromycin (-)	500 mg	10 mL inj	$
Erythromycin (-)	1,000 mg	10 mL inj	$
Erythromycin(Eryped)	200 mg	5 mL Susp	$
Erythromycin(ERY-TAB)	250 mg	1 tab DR Tab	$
Fidaxomicin(Dificid)	200 mg	1 tablet	$$$$

Miscellaneous antibiotics

Atovaquone (MEPRON)	750 mg	5 mL Susp	$
Aztreonam Inj (AZACTAM)	500 mg	injection	$
Aztreonam Inj (AZACTAM)	1,000 mg	1 vial injection	$$
Aztreonam Inj (AZACTAM)	2,000 mg	1 vial injection	$$
Bacitracin irrigation (-)	0	250 mL Irrigation	$
Bacitracin (BACITRACIN)	50,000 unit	1 vial injection	$
Chloramphenicol (CHLOROMYCETIN)	1,000 mg	1 vial injection	$$
Colistimethate (-)	150 mg	1 vial injection	$$
DAPTOmycin (CUBICIN)	1 mg	0.02 mL inj	$$$$
Daptomycin (Cubicin)	500 mg	1 vial Insert	$$$$
Erythromycin-sulfisoxazole susp (Eryped)	0	5 mL suspension	$
Linezolid premix bag (ZYVOX)	600 mg	300 mL Bag	$
Linezolid (ZYVOX)	600 mg	1 tablet	$$
Pentamidine INHALATION(NEBUPENT)	300 mg	1 vial suspension	$$
Sulfamethoxazole-trimethoprim DS(BACTRIM DS)		1 tab DS Tab	$
Sulfamethoxazole-trimethoprim inj (BACTRIM)	160 mg	10 mL inj	$
Sulfamethoxazole-trimethoprim inj (BACTRIM)	2,400 mg	30 mL inj	$
Sulfamethoxazole-trimethoprim ss (BACTRIM)		1 tablet	$
Sulfamethoxazole-trimethoprim susp(SULFATRIM)		20 mL Susp	$
Vancomycin vial (advantage)(Vancomycin)	500 mg	1 vial injection	$
Vancomycin vial (advantage)(-)	1 g	1 vial injection	$
Vancomycin vial(VANCOMYCIN HCL)	500 mg	5 mL inj	$
Vancomycin vial(VANCOMYCIN HCL)	1,000 mg	10 mL inj	$

Penicillins

Aminopenicillins

Amoxicillin susp (TRIMOX)	250 mg	5 mL suspension	$
Amoxicillin (AMOXICILLIN)	250 mg	1 capsule	$
Ampicillin cap (PRINCIPEN)	250 mg	1 capsule	$
Ampicillin susp (PRINCIPEN)	250 mg	5 mL suspension	$
Ampicillin vial (AMPICILLIN)	125 mg	1.2 mL injection	$
Ampicillin vial (AMPICILLIN)	250 mg	1 mL injection	$
Ampicillin vial (AMPICILLIN)	500 mg	2 mL injection	$
Ampicillin vial (AMPICILLIN)	1,000 mg	3.5 mL injection	$
Ampicillin vial (AMPICILLIN)	2,000 mg	1 vial injection	$

Beta-lactamase inhibitors

Amoxicillin-clavulanate susp(AUGMENTIN)	200 mg	5 mL suspension	$
Amoxicillin-clavulanate susp(AUGMENTIN)	400 mg	5 mL suspension	$
Amoxicillin-clavulanate susp(AUGMENTIN)	600 mg	5 mL suspension	$
Amoxicillin-clavulanate(-)	0	5 mL Powder	$
Amoxicillin-clavulanate(AUGMENTIN)	0	1 tablet	$
Amoxicillin-clavulanate (AUGMENTIN)	0	5 mL Powder	$
Amoxicillin-clavulanate (AUGMENTIN)	500 mg	1 tablet	$
Amoxicillin-clavulanate (AUGMENTIN)	875 mg	1 tablet	$
Ampicillin-sulbactam (UNASYN)	1,500 mg	1 vial injection	$
Ampicillin-sulbactam (UNASYN)	3,000 mg	1 vial injection	$
Piperacillin-tazo premix (ZOSYN)	2.25 g	50 mL Bag	$
Piperacillin-tazo premix (ZOSYN)	3.375 g	50 mL Bag	$
Piperacillin-tazo (ZOSYN)	2.25 g	10 mL inj	$
Piperacillin-tazo (ZOSYN)	3.375 g	10 mL inj	$

Natural penicillins

Penicillin (IM ONLY)(BICILLIN L-A)	1.2 MU	2 mL LA inj	$
Penicillin GK (Penicillin G Potassium)	1 MU	2 mL inj	$$$
Penicillin G potassium	3 MU	50 mL Bag	$
Penicillin G sodium vial(-)	5 MU	10 mL inj	$$
Penicillin susp(Veetids)	125 mg	5 mL REC Powder	$
Penicillin susp(Veetids)	250 mg	5 mL REC Powder	$
Penicillin VK tab(-)	250 mg	0.5 tablet	$

Penicillinase resistant penicillins

Dicloxacillin (DICLOXACILLIN SODIUM)	500 mg	1 capsule	$
Nafcillin (-)	1,000 mg	10 mL injection	$
Nafcillin (NAFCIL)	2,000 mg	10 mL injection	$
Nafcillin (NAFCIL)	1,000 mg	1 vial injection	$

Quinolones

ciprofloxacin premix bag(CIPRO I.V.)	400 mg	200 mL Bag	$
Ciprofloxacin (CIPRO)	100 mg	1 tablet	$
Ciprofloxacin (CIPRO)	250 mg	1 tablet	$
Ciprofloxacin (CIPRO)	500 mg	1 tablet	$
Ciprofloxacin (CIPRO)	500 mg	5 mL Susp	$
Ciprofloxacin (CIPRO)	750 mg	1 tablet	$
Levofloxacin premixed bag (LEVAQUIN)	250 mg	50 mL Bag	$
Levofloxacin premixed bag (LEVAQUIN)	500 mg	100 mL Bag	$
Levofloxacin premixed bag (LEVAQUIN)	750 mg	150 mL Bag	$
Levofloxacin (LEVAQUIN)	250 mg	1 tablet	$
Levofloxacin (LEVAQUIN)	500 mg	1 tablet	$
Levofloxacin (LEVAQUIN)	750 mg	1 tablet	$$$$
Moxifloxacin (AVELOX)	400 mg	1 tablet	$

Sulfonamides

sulfaDIAZINE(-)	500 mg	1 tablet	$
sulfaSALAzine(Azulfadine)	500 mg	1 tablet	$

Tetracyclines

Demeclocycline (DECLOMYCIN)	150 mg	1 tablet	$
Doxycycline inj (VIBRAMYCIN)	100 mg	1 vial injection	$
Doxycycline susp (VIBRAMYCIN)	25 mg	5 mL suspension	$
Doxycycline (VIBRAMYCIN)	100 mg	1 tablet	$
Minocycline (MINOCIN)	100 mg	1 vial injection	$$

Urinary anti-infectives

Fosfomycin (MONUROL)	3 g	suspension	$$
Nitrofurantoin monohydrate (MACROBID)	100 mg	1 capsule	$
Nitrofurantoin (MACROBID)	50 mg	1 capsule.	$

Antimalarial agents

Antimalarial quinolines

quiNINE(Qualaquin)	324 mg	1 capsule	$

Miscellaneous antimalarials

Pyrimethamine (DARAPRIM)	25 mg	1 tablet	$
QuiNINE (QuiNINE sulfate)	260 mg	1 tablet	$
Quinine(QUININE SULFATE)	324 mg	1 capsule	$

Antituberculosis agents

Nicotinic acid derivatives

isoniazid(INH)	300 mg	1 tablet	$
pyrazinamide(-)	500 mg	1 tablet	$

Rifamycin derivatives

Rifampin inj (RIFADIN IV)	600 mg	10 mL inj	$$$
Rifampin (RIFADIN)	300 mg	1 capsule	$

Antiviral agents

Adamantane antivirals

amantadine syrup(Symmetrel)	50 mg	5 mL Syrup	$
amantadine(symmetrel)	100 mg	1 capsule	$

Antiviral chemokine receptor antagonist			
maraviroc(Selentry)	300 mg	1 tablet	$
Antiviral combinations			
abacavir-lamivudine (EPZICOM)	0	1 tablet	$$
emtricitabine-tenofovir 200/300 mg (TRUVADA)	0	1 tablet	$$
Integrase strand transfer inhibitor			
Raltegravir (ISENTRESS)	400 mg	1 tablet	$
Miscellaneous antivirals			
Foscarnet (FOSCAVIR)	24 mg	1 mL injection	$
Foscarnet (FOSCAVIR)	6,000 mg	250 mL injection	$
Palivizumab (SYNAGIS)	50 mg	0.5 mL injection	$$$$
Palivizumab (SYNAGIS)	100 mg	1 mL injection	$$$$
Neuraminidase inhibitors			
Oseltamivir (TAMIFLU)	60 mg	5 mL suspension	$
Oseltamivir (TAMIFLU)	75 mg	1 capsule	$
Zanamivir (RELENZA)	5 mg	0 Powder	$
NNRTIs			
efavirenz(SUSTIVA)	200 mg	0 Cap	$
efavirenz(Sustiva)	600 mg	1 tablet	$
nevirapine(VIRAMUNE)	50 mg	5 mL Susp	$
nevirapine(Viramune)	200 mg	1 tablet	$
NRTIs			
Lamivudine(EPIVIR)	150 mg	0 Tab	$
LamiVUDine (EPIVIR)	150 mg	1 tablet	$
LamiVUDine-zidovudine (COMBIVIR)	0	1 tablet	$
Stavudine (ZERIT)	40 mg	1 capsule	$
Zidovudine (RETROVIR)	200 mg	20 mL injection	$
Zidovudine (RETROVIR)	2,400 mg	240 mL Syrup	$
Zidovudine (RETROVIR)	100 mg	1 capsule	$
Protease inhibitors			

Indinavir (CRIXIVAN)	400 mg	Cap	$
Indinavir (CRIXIVAN)	400 mg	1 capsule	$
Nelfinavir (VIRACEPT)	250 mg	1 tablet	$$

Purine nucleosides

Acyclovir Inj (ZOVIRAX)	500 mg	1 vial inj	$$
Acyclovir susp (ZOVIRAX)	800 mg	20 mL Susp	$
Acyclovir (ZOVIRAX)	200 mg	1 capsule	$
Acyclovir (ZOVIRAX)	800 mg	1 tablet	$
Cidofovir (VISTIDE)	375 mg	5 mL injection	$$$$
Famciclovir (FAMVIR)	250 mg	1 tablet	$
Famciclovir (FAMVIR)	500 mg	1 tablet	$
Ganciclovir (CYTOVENE)	500 mg	1 vial injection	$$
Ribavirin Inh soln (VIRAZOLE)	6 g	0 Inhaler	$$$$
ValACYclovir (VALTREX)	500 mg	1 tablet	$

Antimicrobial Clinical Practice Guidelines

Dosing for Vancomycin

Empiric Dosing

1. Set Loading dose 25 mg x Actual Body Weight (Max 2 g) = _____ mg

2. Set Maintenance dose = 15-20 mg/ kg x Actual Body Weight (max dose of 2 g to start, based on severity of infection) – Round all doses to nearest 250 mg

3. Set Interval

Determine CrCl and determine frequency

CrCl (ml/min)	Frequency (hr)
> 60	q 12h
40-60	q24h
25-39	q 48h
10-24	per levels
<10	see below

4. See below

Dosing in morbidly obese patients:

1. Empiric dosing should be dosed on total body weight at 15mg/Kg q12 hrs for patients with normal renal function. Maximum dose 2 grams, rounded to the nearest 250mg. For patients with impaired renal function, refer to frequency table above.

2. Trough levels should be drawn on all obese patients. Vancomycin is cleared much faster in this population vs the non-obese population. Hence, the need for q8hr dosing is not unusual when renal function is normal.

3. Estimated creatinine clearance should be calculated using the Salazar-Corcoran equation, which has shown to be a better predictor of CrCl in obese patients when compared to the Cockroft-Gault equation.

Dosing in dialysis patients:

Individualize patient doses based on weight, indication, dialysis schedule, and dialysis filter. At LMH, the filters are high flux.

Pts with residual kidney function (RRF): Dose per weight/indication, monitor every 3 days, redose per weight when levels are less than 10mcg/ml. Drug should be given post dialysis and levels should be drawn 1 hour post dialysis to compensate for Vancomycin redistribution.

Anuric: Dose per weight, monitor every 5 days, redose per weight when levels are less than 10 mcg/ml.

Intradialytic administration at KDS is generally the following:

High flux Hemodialysis (HF HD) – in patients less than 50Kg, 1 gram IV loading over the last hour of HD and 500mg IV in the last hour of dialysis during each of the following HD sessions. Draw level on the first treatment following the patient's weekend. Call nephrologist if level is <5 or >20. For patients 50 to 70Kg, initial dose is 1.5grams, maintenance is 750mg. For patients greater than 70Kg, initial dose is 2 grams over last 1.5 hours of dialysis, maintenance doses are 1 gram.[1,2]

Monitoring Guidelines

Therapeutic Plasma Concentrations

LMH Normal – Trough 5-15 mcg/ml
LMH Critical Value: > 25 mcg/ml

Recommended Goals – Troughs should be obtained just prior to the next dose at steady-state conditions

Mild to Moderate Infections	*Severe Infections*
Goal: 10-15 mcg/ml	Goal: 15 to 20 mcg/ml (if over 20 and less than 25, use clinical judgement)
Examples: Empiric therapy, skin and skin structure infections	Examples: Endocarditis, osteomylitis, meningitis, bacteremia and hospital acquired pneumonia caused by Staphylococcus

Monitoring Guideline

Obtain a serum creatinine weekly, more frequently when given with nephrotoxic medications

Monitor CBC, Tmax to evaluation drug effectiveness.

Monitoring Serum Vancomycin

- Monitoring is NOT recommended in the following settings:
  - Patients treated for less than five days.
  - Patients receiving oral vancomycin, unless treated for greater than 3 weeks at 1 gram per day with diminished renal function.
  - Patients with stable renal function who are treated empirically for up to 14 days for mild to moderate infections.

- Monitoring trough serum concentrations IS recommended in the following settings:
  - Patients who will need continued IV treatment (>five days) for moderate to severe infections.
  - Prolonged (>14 days) treatment.
  - Serious or life-threatening infections.
  - End-stage renal disease in patients who are likely to receive more than one dose.
  - Co-administration of nephrotoxic drugs (e.g., aminoglycosides, amphotericin B, cyclosporine).
  - Extremes of body weight - (Morbidly obese patients)
  - Patients with rapidly changing or unpredictable renal function.

- Monitoring peak serum concentrations IS not recommended[1]

References:

1. Rybak M, Lomaestro, B, Rotschafer J, et al., Therapeutic monitoring of vancomycin in adult patients: A consensus review of the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, and the Society of Infectious Diseases Pharmacists Am J Health-Syst Pharm. 2009; 66:82-98

2. Pallotta,KE, Manley, HJ. Vancomycin Use in Patients Requiring Hemodialysis: A Literature Review Seminars in Dialysis, Vol21, No1 (January-February) 2008 pp.63-70.

3. KDS Vancomycin dosing for Dr. Solcher and Dr. Duvuur - April 2009

4. Cockroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. Nephron 1975;16:31-41

LMH DEPARTMENT OF PHARMACY
ANTI-INFECTIVES RENAL DOSING CHART

ANTI-INFECTIVE	NORMAL DOSE	CRCL in ml/min	RENAL DOSE ADJUSTMENTS
Acyclovir **IV** *Use **ideal body weight***	5 mg/kg IV Q8 hours CNS infections: 10 mg/kg IV q8 hours	25-49: 10-24: <10 HD	Frequency to Q12 hours Frequency to Q24 hours 50% normal dose IV Q24 hours Q24 hours schedule dose to be given after dialysis
Acyclovir PO	Dose and Renal Adjustments Vary by Indication. Please refer to appropriate drug reference.		
Amikacin *Note: Consultation with ID & Pharmacy recommended.*	Extended Interval Dosing: 15 mg/kg IV Q24 hours *Note: draw level 6-14 hours after 1st dose*	***** 40-59: 30-39: <30	**Extended Interval Dosing:** 15 mg/kg IV Q36 hours 15 mg/kg IV Q48 hours AVOID, use conventional dosing
	Conventional Dosing: 5-7.5 mg/kg/dose Q8 hours *Note: Peak & trough levels should be monitored*	***** 40-60: 20-39: <20: HD:	**Conventional Dosing:** 5-7.5 mg/kg Q12 hours 5-7.5 mg/kg Q24 hours 5-7.5 mg/kg then monitor level 5-7.5 mg/kg Q48-72h, monitor level prior to HD to determine dosing needs
Amoxicillin	250-500 mg PO Q8 hours	10-30: <10: HD:	500 mg PO Q12 hours 500 mg PO Q24 hours 500 mg PO q24 hours schedule dose to be given after dialysis
Amoxicillin/ Clavulanate	875 mg PO Q12 hours	10-30: <10:	500/125 mg PO Q12 hours 250 mg PO Q12 hours

	500 mg PO Q8 hours	HD:	250-500 mg PO q24 hours schedule dost to be given after dialysis
	1000/62.5 mg PO q12h (XR formulation)	< 30	XR formulation NOT recommended with CrCl < 30
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Ampicillin IV	**Continuous Infusion:** 8-12 g IV over 24 hours	***** 30-49: 10-29: <10: HD:	**Continuous Infusion** 8 g IV over 24 hours 6-8 g IV over 24 hours Use Traditional Dosing Use Traditional Dosing
	Conventional Dosing: 1-2 g IV Q4 hours *Note: 2g dose is recommended for endocarditis, meningitis and bacteremia*	***** 30-49: 10-29: <10: HD:	**Conventional Dosing** 1-2 g IV Q6 hours 1-2 g IV Q12 hours 1-2 g IV Q12 hours 1-2 g IV Q12 hours
Ampicillin/ Sulbactam	1.5 g IV Q6 hours	30-49: 15-29: 5-14: HD:	1.5-3 g IV Q8 hours 1.5-3 g IV Q12 hours 1.5-3 g IV Q24 hours 1.5-3 g IV Q24 hours – GIVE AFTER HD
Azithromycin	Usual: 500mg PO x 1, then 250 mg PO Q24 hours x 4-10 days or 500 mg PO Q24 hours x 3 days or 1 gm PO as a single dose *Note: Dose and duration vary by indications. Please see appropriate reference .*		
Aztreonam	1-2 g IV Q8 hours *Interval to q6 hours for severe infections (esp. P.aeruginosa)*	10-29: <10: HD:	50% of usual dose at usual interval 25% of usual dose at usual interval 500 mg IV Q12 hours
Cefaclor PO	ER: 500mg PO Q12 hours RR: 250-500 mg PO Q8-12h	<10: HD:	Reduce dose by 50% Reduce dose by 50% - Give AFTER HD
Cefadroxil PO	1000 mg PO Q12 hours *Indication based alternative dosing: Please see appropriate reference*	25-50: 10-25: <10:	500 mg PO Q12 hours 500 mg PO Q24 hours 500 mg PO Q36 hours

Cefazolin	1 g IV Q8 hours *Note: >= 80 kg or severe infections may use 2 g*	10-30: <10: HD:	Frequency to Q12 hours Frequency to Q24 hours Frequency to Q24 hours schedule dose to be given after dialysis
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Cefepime	1 g IV Q8-12 hours	30-49: 10-29: <10: HD:	1 g IV Q12 hours 1 g IV Q24 hours 1 g IV Q24 hours 1 g IV Q24 hours - Give AFTER HD
	CNS infections or febrile neutropenia 2 g IV Q8 hours	***** 30-49: 10-29: <10: HD:	**CNS Infections or febrile neutropenia** 2 g IV Q12 hours 2 g IV Q24 hours 1 g IV Q24 hours 1 g IV Q24 hours - Give AFTER HD
Cefixime	400 mg PO Q24 hours or 200 mg PO Q12 hours *Note: alternate dosing available for STD, please see appropriate drug information reference.*	21-60: <20 HD:	75% dose PO Q24 hours 50% dose PO Q24 hours 75% dose PO Q24 hours, schedule dose to be given after dialysis
Cefotaxime	1-2 g IV Q4-8 hours *Note: Dose and frequency vary by indications. Please see appropriate drug information reference.*	10-50: <10 HD:	Administer Q6-12 hours Administer Q24 hours 1-2 g IV Q24 hours, schedule dose to be given after dialysis
Cefotetan	1 g IV Q12 hours *Note:>=80 kg may use 2 g*	10-30: <10: HD:	Frequency to Q24 hours Frequency to Q48 hours 25% dose IV Q24 hours non-HD days, 50% dose on HD days, schedule dose after dialysis
Cefoxitin	1 g IV Q6 hours *Note:>=80 kg may use 2 g*	10-49: <10:	1 g IV Q8 hours 1 g IV Q12 hours
Cefpodoxime	200-400 mg PO Q12 hours	<30:	200-400 mg PO Q24 hours

		HD:	200-400 mg PO 3 x week after HD
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Cefprozil	Sinusitis: 250-500mg PO Q12 Pharyngitis/Tonsillitis: 500 mg PO Q24 hours COPD exac/bronchitis: 500 mg PO Q12 hours Skin: 250 mg PO Q12 hours or 500 mg PO Q12-24 hours	<30: HD:	Give 50% of dose Give 50% of dose schedule dose to be given after hemodialysis
Ceftaroline	600 mg IV Q12 hours	31-50: 15-30: <15: HD:	400 mg IV Q12 hours 300 mg IV Q12 hours 200 mg IV Q12 hours 200mg IV Q12 hours
Ceftazidime	1 g IV Q8 hours *CNS infections: Use 2g dose with same frequency*	30-49: <30: HD:	1 g IV Q12 hours 1 g IV Q24 hours Load with 1 g then give 1 g after each HD session
Ceftriaxone	Meningitis or CNS Infection: 2 g IV Q12 hours For all indications other than CNS: 1 g IV Q24 hours	No renal adjustments needed	
Cefuroxime **IV**	750mg-1.5g IV Q8 hours *Note: Frequency can be increased to Q6 hours for life threatening infections*	10-20: <10: HD:	750 mg IV Q12 hours 750 mg IV Q24 hours 750 mg IV after each dialysis session
Cefuroxime **PO** tab	250-500 mg PO Q12 hours *Note: tablet dosing not equivalent to suspension, we do not carry suspension*	<10: HD:	250-500 mg Q24 hours 250-500 mg PO q24 hours schedule dost to be given after dialysis
Cephalexin	500 mg PO Q6 hours	10-30: <10:	500 mg PO Q8 hours 500 mg PO Q12 hours

		HD:	250-500 mg PO q24 hours schedule dost to be given after dialysis
Ciprofloxacin **IV**	400 mg IV Q12 hours HAP or VAP: 400 mg IV Q8 hours	<30 HD:	200-400 mg IV Q24 hours 200 mg IV Q24 hours schedule dose to be given after dialysis
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Ciprofloxacin **PO**	500 mg PO Q12 hours	10-29: <10: HD:	250 mg PO Q12 hours 250 mg PO Q24 hours 250 mg PO Q24 hours schedule dose to be given after dialysis
Clarithromycin	500 mg PO Q12 hours	10-29: <10: HD:	250 mg PO Q12 hours 250 mg PO Q24 hours 250 mg PO Q24 hours schedule dose to be given after dialysis
Clindamycin **IV**	600 mg IV Q8 hours, 900 mg IV Q8 hours for necrotizing faciitis *Note: For patients >100 kg 900 mg IV Q8 hours may be used*	No renal adjustment needed	
Clindamycin **PO**	150-450 mg PO q6-8 hours (varies by indication, please use appropriate reference)	*Note: For patients >100 kg 450 mg PO Q6 hours may be used*	
Daptomycin	4-6 mg/kg IV Q24 hours *Note: Not to be used for infections in the lungs; 4 mg/kg for UTI/SSSTI*	<30: HD:	4-6 mg/kg IV Q48 hours 4-6 mg/kg IV Q48 hours schedule dose to be given after dialysis
Dicloxacillin	125-500mg PO Q6 hours	No adjustment needed	
Doxycycline **IV** or **PO**	100mg Q12 hours	No adjustment needed	
Ertapenem	1000 mg IV Q24 hours	<30: HD:	500 mg IV Q24 hours 500 mg IV Q24 hours schedule dose to be given after dialysis
Erythromycin **IV**	500-1000 mg IV Q6 hours	<10: HD/CAPD:	50% PO/IV dose at same interval Dose the same as CrCl <10 ml/min
Erythromycin **PO**	Base: 250-500mg PO Q6-12 h EES: 400-800mg PO Q6-12 h		

ANTI-INFECTIVE	NORMAL DOSE	CRCL in ml/min	RENAL DOSE ADJUSTMENTS
Ethambutol	Initial: 15 mg/kg PO Q24 hrs Retreatment: 25 mg/kg PO Q24 hours x 60 days, then 15 mg/kg/day *Note: Should not be used alone; Monthly eye exams recommended on high dose regimen; max dose 2.5 gm*	***** 10-50: <10: HD: ***** 10-50: <10: HD:	Initial Treatment: 15 mg/kg PO Q24-36 hours 15 mg/kg PO Q48 hours Administer dose after dialysis Retreatment: 25 mg/kg PO Q24-36 hours 25 mg/kg PO Q48 hours Administer dose after dialysis
Famciclovir	250-500 mg PO Q8 hours 500 mg PO Q8 hours for VZV *Note: no clear adjustment recommendations in CAPD*	40-59: 20-39: <20: HD:	same dose Q12 hours same dose Q24 hours 50% dose Q24 hours 50% after each dialysis session
Fidaxomicin	200 mg PO Q12 hours	No adjustment needed	
Fluconazole IV or PO	*Invasive candidiasis: 800 mg (12 mg/kg) load x1, then 400 mg (6 mg/kg) PO/IV Q24 hours	10-29: <10: HD: CAPD:	Load x1, then 50% PO/IV dose Q24 hours Load x1, then 25% PO/IV dose Q24 hours Load x1, then 400 mg (6 mg/kg) after HD 3x/weekly 50% PO/IV Q24 hours
	*Esophageal/oropharyngeal candidiasis: 200 mg PO/IV Q24 hours for esophageal; 100 mg Q24 hours for oropharyngeal	<30: HD: CAPD:	50% PO/IV Q 24 hours 100% PO/IV after each dialysis session 50% PO/IV Q24 hours

	Note: Some indications may require different dosing, please refer to appropriate drug reference		
Fosfomycin **PO**	Uncomplicated cystitis: 3 gm x1 Complicated cystitis: 3 gm Q48 hours	<50: <50:	Same dose 3 gm Q72 hours
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Ganciclovir **IV**	Induction: 5 mg/kg IV Q12 hours Maintenance: 5 mg/kg IV Q24 hours	***** 50-69: 25-49: 10-24: <10: HD: ***** 50-69: 25-49: 10-24: <10: HD:	**Induction:** 2.5 mg/kg IV Q12 hours 2.5 mg/kg IV Q24 hours 1.25 mg/kg IV Q24 hours 1.25 mg/kg IV 3 x week 1.25 mg/kg IV 3 x week schedule dose to be given after hemodialysis **Maintenance:** 2.5 mg/kg IV Q24 hours 1.25 mg/kg IV Q24 hours 0.625 mg/kg IV Q24 hours 0.625 mg/kg IV 3 x week 0.625 mg/kg IV 3 x week schedule dose to be given after hemodialysis
Ganciclovir **PO**	1000 mg PO Q8 hours	50-69: 25-49: 10-24: <10 HD:	1500 mg PO Q24h or 500 mg PO Q8h 1000 mg PO Q24h or 500 mg PO Q12h 500 mg PO Q24 hours 500 mg PO 3 x week 500 mg PO 3 x week schedule dose to be given afer hemodialysis
Gentamicin *Note: Consultation with Pharmacy recommended*	Extended Interval Dosing: 7 mg/kg IV Q24 hours *Note: draw level 6-14 hours after 1st dose*	***** 40-59: 30-39: <30 *****	**Extended Interval Dosing:** 7 mg/kg IV Q36 hours 7 mg/kg IV Q48 hours AVOID, use conventional dosing **Conventional Dosing:**

Exclusion to Extended Interval: Pregnancy, breastfeeding, burns (>20% body), ascites, Enterococcoal endocarditis, HD or CrCl < 20 ml/min	Conventional Dosing: 1-2.5 mg/kg/dose Q8 hours *Note: Peak & trough levels monitored, consult pharmacy*	40-60: 20-39: <20: HD:	1-2.5 mg/kg Q12 hours 1-2.5 mg/kg Q24 hours 1-2.5 mg/kg then monitor level 2-3 mg/kg Q48-72h, monitor level prior to HD to determine dosing needs
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Imipenem/ Cilastatin	250-1000mg IV Q6-8 hours Usually 500 mg IV Q6 hours *Note: max dose 50mg/kg/day or 4g/day* *Note: Dose varies by severity of infection & organism sensitivity*	30-70: 20-30: 6-20: <5: HD:	Decrease daily dose by 50% & divide Q6-8 hours (round to nearest 250 mg) Decrease daily dose by 63% & divide q8-12 hours (round to nearest 250 mg) Decrease daily dose by 75% & divide Q12 hours (round to nearest 250 mg) Not recommended unless HD being started Decrease daily dose by 75% & divide q12 hours (round to nearest 250 mg); dose after dialysis on dialysis day
Isoniazid	300 mg PO Q24 hours (5 mg/kg PO Q24 hours); max of 300 mg; HD/CAPD: dose after dialysis		
Itraconazole	200 mg PO Q8-24 hours (histo/cocci/blasto: load with 200 mg Q8 hours x2 days, then 200 mg Q12 hours) *Notes: avoid PPIs/H2 blockers; suspension on empty stomach; capsules with meal or acidic drink; consider monitoring SS trough after 5-7 days (>1 mg/dL, sum of itraconzole and hydroxy-itraconazole)*		
Ketoconazole	200-400 mg PO Q24 hours Note: Dose and frequency vary by indications. Please see appropriate drug information reference.		
Levofloxacin IV or PO	Pneumonia/Pseudomonas: 750 mg Q24 hours	20-49: 10-19:	Pneumonia /Pseudomonas: 750mg Q48 hours Other: 500 mg load then 250 mg Q24h Pneumonia /Pseudomonas: 500 mg Q48 hours

	Other Indications: 500 mg Q24 hours	<10: HD:	Other: 500 mg load then 250 mg Q48h Pneumonia /Pseudomonas: 250-500 mg Q48h Other: 250 mg Q48 hours Pneumonia /Pseudomonas: 250-500 mg Q48h Other: 250 mg Q48 hours
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Linezolid IV or PO	600 mg Q12 hours	No adjustment needed	
Meropenem	500 mg IV Q6 hours UTI: 500 mg Q8 hours Meningitis, CF, meropenem MIC of 4 mg/dL: 2 gm Q8 hours	25-49: 10-24: <10/HD: HD/CAPD	500 mg IV Q8 hours (UTI: 500 mg Q12 hours; meningitis, etc: 2 gm Q 12 hours) 500 mg IV Q12 hours (UTI: 250 mg Q12 hours; meningitis, etc: 1 gm Q12 hours) 500 mg IV Q24 hours (UTI: 500 mg Q24 hours; meningitis, etc: 1 gm Q24 hours) dose as CrCl <10, given after dialysis on dialysis days
Metronidazole IV or PO	500 mg Q12 hours if C difficile is not suspected 500 mg Q8 hours if C difficile is suspected	<10: HD/CAPD	Consider 50% at same interval if >14 day duration Give after dialysis on dialysis days
Micafungin IV	100 mg IV Q24 hours	No adjustment needed	
Minocycline **PO**	100 mg PO Q12 hours	<10: HD:	100 mg Q24 hours 100 mg Q24 hours
Nafcillin	Continuous Infusion: 8-12 g/day *Note: 12 g/day recommended for endocarditis* Intermittent Dosing: 2 g IV Q4-6 hours	No adjustment needed	

Nitrofurantoin	100 mg PO Q12 hours	<60, HD/CAPD:	*<50, HD/CAPD: Use is not recommended - will not reliably reach useful concentrations in urine and will have increased risk of toxicity.*
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Oseltamivir	Treatment: 75 mg PO Q12 hours Prophylaxis: 75 mg PO Q24 hours	<30: HD:	Prophylaxis: 75 mg PO Q48 hours Treatment/Prophylaxis: 30 mg PO x 1 before HD then after every other dialysis session x 3 doses
Penicillin G **IV**	Continuous Infusion: 18-24 million units/day Intermittent Dosing: 2-3 million units IV Q4-6 hours *Note: Doses varies by indication. Please refer to appropriate drug reference.*	***** 10-50: <10 HD: CAPD: ***** 10-50: <10:	**Continuous Infusion** 12-18 million units/day (75% IV at same time interval) 6-12 million units/day (75% IV at same time interval) Dose as CrCl <10, given after dialysis on dialysis days Dose a CrCl <10. **Intermittent Dosing** 1-2 million units/day IV Q4-6 hours 1 million units/day IV Q6 hours
Penicillin VK **PO**	500 mg PO Q6 hours *Note: Doses varies by indication. Please refer to appropriate drug reference.*	10-50: <10: HD:	500 mg PO Q8 hours 500 mg PO Q12 hours Give dose after dialysis on dialysis days
Piperacillin/ Tazobactam	Pneumonia/Pseudomonas: 4.5 g IV Q6 hours	20-39:	Pna/Pseudomonas: 3.375 g IV Q6 hours

	Other Indications: 3.375 g IV Q6 hours or 4.5 g IV Q8 hours	<20: HD: CAPD:	Other: 2.25 g IV Q6 hours Pna/Pseudomonas: 2.25 g IV Q6 hours Other: 2.25 g IV Q8 hours Pna/Pseudomonas: 2.25 g IV Q8 hours Other: 2.25 g IV Q8 hours Supplement Dose after HD: 0.75g Dose as CrCl< 20
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Quinipristin/ Dalfopristin	7.5 mg/kg IV Q8-12 hours *Note: Synercid should be used with discretion due to cost and to maintain susceptibility profile*		
Rifampin	Doses vary by indication. Please refer to appropriate drug information reference. *Note: Should not be used alone; screen for drug interactions*		
Rimantadine	100mg PO Q12 hours	<30:	100 mg PO Q24 hours
Terbinafine	500 mg PO Q12 hours 250 mg PO Q24 hours	<50:	Use not recommended
Ticarcillin/ Clavulanate	Severe or Pseudomonas: 3.1 g IV Q4 hours Moderate: 3.1 g IV Q6 hours UTI: 3.1 g IV Q6-8 hours *Note: <60kg dose 200-300mg/kg/day divided q4-6 h*	30-60: 10-30: <10: HD: CAPD:	3.1 g IV Q8 hours 3.1 g IV Q12 hours 2 g (ticarcillin) IV Q12 hours <10 & hepatic dysf: 2 g (ticarcillin) IV Q24 hours 2 g (ticarcillin) IV Q12 hours plus 3.1 g after HD session Dose as CrCl <10.
Tobramycin *Note: Consultation with Pharmacy recommended.*	Extended Interval Dosing: 7 mg/kg IV Q24 hours *Note: draw level 6-14 hours after 1st dose* Conventional Dosing: 1-2.5 mg/kg/dose Q8 hours	***** 40-59: 30-39: <30 ***** 40-60: 20-39:	**Extended Interval Dosing:** **Frequency determined by levels/Hartford nomogram** 7 mg/kg IV Q36 hours 7 mg/kg IV Q48 hours AVOID, use conventional dosing **Conventional Dosing (empiric, before levels):** 1-2.5 mg/kg Q12 hours 1-2.5 mg/kg Q24 hours

	Note: Peak & trough levels monitored, consult pharmacy	10-20: <10: HD:	1-2.5 mg/kg Q48 hours 1-2.5 mg/kg Q72 hours 2-3 mg/kg Q48-72h, monitor level prior to HD to determine dosing needs
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Trimethoprim/ Sulfamethoxazole **PO** (1 Bactrim DS tablet = 160mg(TMP)/800(SMX) *Note: When changing from IV to PO use the same trimethoprim dose as IV*	MRSA cellulitis (or Skin/skin structure infection/other infections): 1-2 DS tablets Q12 hours Other Indications: 1 DS tablet Q12 hours	15-30: <15: HD:	Increase interval to Q24 hours or Decrease dose by 50% (ie. DS to SS) AVOID or decrease dose 50% (ie. DS to SS) <u>AND</u> increase interval to Q48 hours Dose according to dosage for <15, schedule dose to be given after dialysis
Trimethoprim/ Sulfamethoxazole **IV** *Note: Dosing is based on Trimethoprim component*	<u>Pneumocystis treatment:</u> 15-20 mg/kg/day in 3-4 divided doses <u>Severe Infections:</u> 8-10 mg/kg/day in 2-4 divided doses	15-30 <15	50% of usual dose in 2-4 divided doses AVOID if possible ***Pneumocystis treatment:*** 15-20 mg/kg/dose Q48 hours or 7-10 mg/kg/day divided in 1-2 doses ***Severe Infections:*** 8-10 mg/kg/dose Q48 hous or 4-5 mg/kg/day divided in 1-2 doses

		HD:	Dose according to dosage for <15, schedule dose to be given after dialysis
ANTI-INFECTIVE	**NORMAL DOSE**	**CRCL in ml/min**	**RENAL DOSE ADJUSTMENTS**
Vancomycin *Note: Consultation with Pharmacy recommended.*	Loading Dose: 20 mg/kg IV x 1 Maintenance: 15-20 mg/kg IV Q8-12 hours Max Dose 2000 mg Round to nearest 250 mg *Note: trough levels should be monitored on patient with expected duration > 3 days*	40-60: 25-39: <24: HD:	15-20 mg/kg IV Q24 hours 15-20 mg/kg IV Q48 hours Dosing adjustments per levels Dosing adjustments per levels
*Dosing, therapeutic goals, and monitoring should be individualized for each patient.			
Troughs of 15-20 mcg/mL are recommended for patients with MRSA bloodstream infections, endocarditis, meningitis, pneumonia, osteomyelitis, and septic arthritis.			
Valacyclovir	250-500 mg PO Q8 hours *Note: Dose and frequency vary by indications. Please see appropriate drug information reference.*		*Note: Renal dose adjustments vary by indication, please refer to appropriate drug reference*
	2g PO q12h	30-49: 10-29: <10:	1g PO q12h 1g PO q12h 500mg PO q24h
	1g PO q8h	30-49: 10-29: <10:	1g PO q12h 1g PO q24h 500mg PO q24h
	1g PO q12h	30-49: 10-29: <10:	no adjustment 1g PO q24h 500mg PO q24h

	1g PO q24h	30-49: 10-29: <10:	no adjustment 500mg PO q24h 500mg PO q24h
	500mg PO q12h	30-49: 10-29: <10:	no adjustment 500mg PO q24h 500mg PO q24h
	500mg PO q24h	30-49: 10-29: <10:	no adjustment 500mg PO q48h 500mg PO q48h
		HD: CAPD:	500mg PO q48h 500mg PO q48h

ANTI-INFECTIVE	NORMAL DOSE	CRCL in ml/min	RENAL DOSE ADJUSTMENTS
Voriconazole **PO**	Loading Dose: 400 mg PO x 1, then 200 mg PO Q12 hours May require dose adjustment in hepatic impairment, consult pharmacy *Note: Consider weight base dosing for obese patients using ADJ BW* *Note: Oral formulation is 95% bioavailable*		
	Note: Screen for drug interactions, dose may need adjustment		
Voriconazole **IV**	Active disease: Loading dose of 6mg/kg q12h x2 doses, then 4mg/kg 12h Prophylaxis: 200mg q12h (100mg q12h if <40kg) Therapeutic drug monitoring is suggested. Voriconazole target trough at steady-state is 2 - 5.5 mg/L.	Renal dysfunction: no adjustment necessary If CrCl < 50, accumulation of IV vehicle may occur (cyclodextrin) – Switch to PO or DC	

Reference: Micromedex, Sanford Guide to Antimicrobial Therapy (42th edition)

INFECTION CONTROL

Contact Information:

IP Telephone – 505-3158
24 hour on-call through intranet text paging system
Medical Director: Dr. Christopher Penn
Director: Ava Trahan 505-3157
Infection Preventionist: 505-3158

Isolation Precautions

Patients with various conditions are placed into isolation to minimize the risk of transmission to other patients and healthcare workers. A full listing of isolation precautions can be found at the CDC Website http://www.cdc.gov/hicpac/pdf/isolation/Isolation2007.pdf These recommendations are from the Centers for Disease Control and Prevention (CDC) There are four major classifications of isolation precautions according to CDC at LMH we add a 5th to highlight correct hand hygiene practice along with cleaning disinfectant specific for one organism:

Standard Precautions

All patients should be cared for using standard precautions. All patients should be considered to potentially harbor a bloodborne pathogen. Standard precautions require adherence to hand hygiene recommendations (at a minimum, hand hygiene using WHO 5 Moments) and use of barrier precautions (gown, gloves, eye-protection, etc.) for contact with blood or body fluids.

Contact Precautions

Contact precautions are utilized in the care of patients infected or colonized with epidemiologically important microorganisms that can be transmitted via direct contact or indirect contact with environmental surfaces and vectors. The most common bacteria requiring contact isolation are MRSA, VRE, and multi-drug resistant gram-negative bacilli. Precautions include:

Private room (cohorting is considered at times of limited bed availability)
Strict adherence to hand hygiene
Gloves
Gowns if contact is anticipated between the healthcare worker's clothing and the patient or patient-care environment
Masks/eye protection if patient has respiratory infection and is coughing/being suctioned or has wound irrigation
Dedicated patient care equipment (stethoscope, scale, etc.)

Contact PLUS Precautions (LMH specific)

Due to prevalence of C. diff infections in the area LMH decided to keep Contact Plus Isolation precautions to highlight correct hand hygiene as well as effective cleaners.

Precautions include:
Private room (cohorting is considered at times of limited bed availability)
Strict adherence to hand hygiene using soap and water
Gloves
Gowns if contact is anticipated between the healthcare worker's clothing and the patient or patient-care environment
Masks/eye protection if patient has respiratory infection and is coughing/being suctioned or has wound irrigation
Dedicated patient care equipment (stethoscope, scale, etc)
Cleaning consideration: Bleach or disinfectant with C. diff claim

Droplet Precautions

Droplet precautions are used for a patient known or suspected to be infected with a pathogen transmitted by respiratory droplets. The most common organisms requiring use of droplet precautions are meningococcus, influenza, and pertussis. Precautions include:
Private room (cohorting is considered at times of limited bed availability)
Strict adherence to hand hygiene
Mask (surgical) upon entering room

Airborne Precautions

Airborne precautions are utilized in the care of patients known or suspected to be infected with pathogens transmitted by airborne droplet nuclei (small particles that can remain suspended in the air). The most common diseases/pathogens requiring airborne precautions are pulmonary tuberculosis, chickenpox, and disseminated varicella. Precautions include:
Private room with negative pressure and special ventilation – contact infection control or access services to get room setup
N-95 respirators are used for care of patients known or suspected to be infected with tuberculosis or other pathogens that are transmitted via an airborne route (Healthcare workers should be fit-tested before wearing N-95 respirators or caring for patients in airborne isolation if current testing is not on file).

In addition to the 4 major transmission-based isolation categories above, additional precautions are utilized in the care of certain immunocompromised patient populations. These precautions are used most commonly for Oncology patients that are found to be profoundly neutropenic and can be instituted in other areas of the hospital for similar patients. The specific measures are more fully described in the Infection Prevention and Control manual posted on the intranet under policy Protective Care Precautions. These measures include the following:
Private room
Strict adherence to hand hygiene
No persons with respiratory infections or other communicable illnesses should enter
No live plants or flowers
No fresh fruit or vegetables

Isolation Precautions Quick Reference

Symptoms	Isolation	DC Isolation
Wound (uncontained draining wound)	Contact	Duration of illness

Diarrhea (acute onset)	Contact	Resolution of diarrhea for 24 hours
Headache (severe) and fever	Droplet	Bacterial meningitis ruled out
Residents/patients from other care facilities:		
*Respiratory symptoms	Droplet	Cultures negative for MRSA
*Cellulitis/wound infection	Contact	Cultures negative for MRSA or VRE
MRSA (suspicious i.e.. Frequent hospitalizations or gram + cocci identified in culture):		
*Respiratory	Droplet+Contact	Cultures negative for MRSA
*Other sites	Contact	Cultures negative for MRSA
Pediatrics		
*Respiratory (fall, winter, spring)	Contact	Etiology known and non-communicable
*Rash (unknown etiology)	Contact	Etiology known and non-communicable
Organism	Isolation	DC Isolation
Adenovirus	Droplet+Contact	Duration of illness
C. diff	Contact+Plus	Diarrhea stops for 48 hours
Chicken Pox	Airborne+Contact	Lesions crusted (avg. 5-7 days)
Croup (peds)	Contact	Duration of illness
Group A Strep	Droplet	24 hours after treatment is started
Impetigo	Contact	Duration of illness
Influenza	Droplet	Duration of illness
Meningitis	Droplet	Until confirmed (H. Influenza & Neisseria meningitides do not DC isolation)
MRSA (excluding sputum)	Contact	Do not DC Isolation
MRSA (sputum/respiratory secretions)	Droplet+Contact	Do not DC Isolation
Mumps	Droplet	Do not DC Isolation
Mycobacterium	Airborne	Until confirmed if TB (do not discontinue TB until physician ordered or IC determines)
Pertussis	Droplet	Duration of illness
Pneumonia		
*Meningococcal	Droplet	24 hours after treatment
*Mycoplasma	Droplet	Duration of illness

Rotavirus	Contact	Duration of illness
RSV (peds)	Contact	Duration of illness
Scabies	Contact	24 hours after treatment
Shingles		
*One dermatome	Contact	Lesions crusted (avg. 5-7 days)
*Dissiminated	Airborne	Lesions crusted (avg. 5-7 days)

For most current copy of guide please refer to LMH intranet Infection Prevention & Control Policy Manual

Removing a Patient from Isolation

MRSA and VRE
Patients infected or colonized with MRSA or VRE may remain colonized for prolonged periods and may continue to shed organisms into the environment, serving as a reservoir for continued transmission. While it is not recommended to decolonize patients the following may be used as a guide if need arises.

To document that a patient is —decolonized, obtain screening cultures (rectal swabs for VRE or nares swabs for MRSA).
-Patient should be off antibiotics for at least 48 hours
-Cultures should be obtained three times, at least one week apart

Tuberculosis

Patients with known or suspected TB can be removed from airborne isolation in the following situations:

a. Suspected TB
-Diagnosis is confirmed to be something other than tuberculosis, and tuberculosis is no longer in the differential diagnosis.
OR
-Three sputum specimens from three separate days are reported as negative for acid fast bacilli (AFB).

b. Smear positive for AFB
-Cultures or other laboratory tests reveal AFB to be other species of AFB (non-tuberculous).

c. Known Pulmonary TB
-Patient is on effective therapy
-Patient is clinically improving
-Sputum smear is AFB-negative on three separate days

Guidelines for Prevention of Central Venous Catheter-Related Infections

1. Insert the central venous catheter (CVC) at the subclavian site unless the site is unavailable or medically contraindicated.
2. Use full sterile barrier precautions in the insertion of a CVC which includes:
Long sleeve sterile gowns
Sterile gloves
Cap

Mask
Full-size sterile drape
Eye protection (bloodborne pathogen precautions)

3. Use 2% chlorhexidine with 70% alcohol for local skin antisepsis. Use repeated back and forth strokes of the applicator sponge for approximately 30 seconds. Use of chlorhexidine is contraindicated in infants less than 2 months of age.
4. If any component of the catheter or kit becomes contaminated, discard and replace with a sterile device or new kit.
5. After insertion, the site should be covered with a sterile, transparent dressing. Dressings should be changed every 7 days and as needed if the dressing becomes loose, damp, or soiled.
6. Catheters placed under emergent or non-sterile conditions should be removed and replaced at a new site when the patient's condition allows.
7. The catheter hub or connector should be scrubbed vigorously with friction with 70% alcohol for at least 5 seconds before the catheter is accessed.
8. Remove unnecessary catheters as soon as possible

Full recommendations and supporting literature are available at http://www.cdc.gov/hicpac/pubs.html

Guidelines for Prevention of Nosocomial Pneumonia

1. Disinfect and sterilize respiratory therapy equipment and ventilator circuits per approved guidelines and recommendations.
2. Practice good standard infection control precautions. Disinfect hands when moving from a dirty area or task to a clean area or task.
3. Remove endotracheal tubes, nasogastric tubes (NG), and other devices as soon as possible.
4. Elevate the head of the bed at 30-45º.
5. Vaccinate with pneumococcal and influenza vaccines in appropriate individuals.

Full recommendations and supporting literature are available at http://www.cdc.gov/hicpac/pubs.html

Guidelines for Prevention of Surgical Site Infections

1. Prophylactic antibiotics should be administered no more than 60 minutes prior to skin incision.
2. If the operation is prolonged, a second dose of antibiotics should be administered depending on the half-life of the antibiotic (cefazolin – administer a second dose at four hours).
3. Dose prophylactic antibiotics based on the weight of the patient (e.g. 2 grams of cefazolin for patients > 80 kg).
4. Continue prophylactic antibiotics for no more than 24 hours after the end of the procedure.
5. Do not remove hair at the operative site unless necessary. If hair is removed, used electric clippers and remove hair in the pre-operative area just prior to the procedure. Do not use a razor blade to remove hair.
6. Thoroughly disinfect the skin at the operative site using an approved disinfectant.
7. Maintain blood glucose levels (< 200 mg/dl), particularly in diabetic patients.
8. Maintain normothermia (temperature ≥36°C).
9. Maintain dressing on a primarily closed incision for 24-48 hours. Do not expose the wound to tap water for at least 48 hours (if healing normally) or longer (for non-intact wound).

Full recommendations and supporting literature are available at http://www.cdc.gov/hicpac/pubs.html

Guidelines for Prevention of Urinary Tract Infections

1. Indwelling urinary catheters should be used only when absolutely necessary, should not be used solely for personnel convenience, and should be discontinued as soon as possible.
2. Hand hygiene should be done immediately before and after any manipulation of the catheter site or apparatus.
3. Use as small a catheter as possible, consistent with good drainage.
4. Secure indwelling catheters properly after insertion to prevent movement and urethral traction.
5. A sterile closed drainage system is to be used with indwelling catheters.
6. The meatal-catheter junction and the entire perineal area shall be washed with a clean washcloth and soap and water daily and as needed.
7. Indwelling catheters should not be changed at arbitrary fixed intervals. In general, if the urine is flowing freely, the catheter is not encrusted, and the drainage bag is functioning well, then there is no need to change the system.

Full recommendations and supporting literature are available at http://www.cdc.gov/hicpac/pubs.html

Bloodborne Pathogen Exposure

If you experience a potential exposure to BBP you should do the following:

1. Stop the procedure, or excuse yourself from continuation, as soon as it is feasible and safe for the patient.
2. Wash the affected area with soap and water.
3. Report your exposure to your supervisor and enter a MIDAS event report.
4. Report to Employee Health Nurse or Business Health during hours and Emergency Department after hours.
5. Follow the instructions given by above providers regarding further evaluation and post-exposure prophylaxis

Reportable Diseases

REPORTABLE DISEASES IN KANSAS for health care providers, hospitals, and laboratories
(K.S.A. 65-118, 65-128, 65-6001 - 65-6007, K.A.R. 28-1-2, 28-1-4, and 28-1-18. Changes effective as of 4/28/2006)

☏ **- Indicates that a telephone report is required by law within four hours of *suspect* or *confirmed* cases to KDHE toll-free at 877-427-7317**

ⓘ **- Indicates that an isolates must be sent to:** Division of Health and Environmental Laboratories
Forbes Field, Building #740, Topeka, KS 66620-0001
Phone: (785) 296-1633

Acquired Immune Deficiency Syndrome (AIDS)
Amebiasis
Anthrax ☏
Arboviral disease (including West Nile virus, Western Equine encephalitis (WEE) and St. Louis encephalitis (SLE)) - indicate virus whenever possible
Botulism ☏
Brucellosis
Campylobacter infections
Chancroid
Chlamydia trachomatis genital infection
Cholera ☏
Cryptosporidiosis
Cyclospora infection
Diphtheria
Ehrlichiosis

Escherichia coli O157:H7 (and other shiga-toxin producing E. coli, also known as STEC) ⓘ
Giardiasis
Gonorrhea
Haemophilus influenza, invasive disease
Hantavirus Pulmonary Syndrome
Hemolytic uremic syndrome, postdiarrheal
Hepatitis, viral (acute and chronic)
Hepatitis B during pregnancy
Human Immunodeficiency Virus (HIV) (includes Viral Load Tests)
Influenza deaths in children <18 years of age
Legionellosis
Leprosy (Hansen disease)
Listeriosis
Lyme disease
Malaria
Measles (rubeola***)*** ☏
Meningitis, bacterial ☏
Meningococcemia ⓘ☏
Mumps ☏
Pertussis (whooping cough) ☏
Plague *(Yersinia pestis)*☏
Poliomyelitis ☏
Psittacosis
Q Fever *(Coxiella burnetii)* ☏
Rabies, human and animal ☏
Rocky Mountain Spotted Fever
Rubella, including congenital rubella syndrome ☏
Salmonellosis, including typhoid fever ⓘ
Severe Acute Respiratory Syndrome (SARS) ⓘ☏
Shigellosis ⓘ
Smallpox ☏
Streptococcal invasive, drug-resistant disease from Group A *Streptococcus* or *Streptococcus pneumoniae* ⓘ
Syphilis, including congenital syphilis
Tetanus
Toxic shock syndrome, streptococcal and staphylococcal
Transmissible Spongioform Encephalopathy (TSE) or prion disease (includes CJD)
Trichinosis
Tuberculosis, active disease ⓘ☏
Tuberculosis, latent infection
Tularemia
Varicella (chickenpox)
Viral hemorrhagic fever ☏
Yellow fever

In addition, laboratories must report:
• Viral load results of reportable diseases
• ALL blood lead levels, as of 12/2002 (KCLPPP/ABLES)
• CD4+ T-lymphocyte count < 500/ µl or CD4+ T-lymphocytes <29% of total lymphocytes

Outbreaks, unusual occurrence of any disease, exotic or newly recognized diseases, and suspect acts of terrorism should be reported within 4 hours by telephone to the Epidemiology Hotline: 877-427-7317

Mail or fax reports to your local health department and/or to:

KDHE Office of Surveillance and Epidemiology, 1000 SW Jackson, Suite 210, Topeka, KS 66612-1274

Fax: 877-427-7318 (toll-free)