I. PURPOSE

The goal of these guidelines is to standardize perioperative antibiotic prophylaxis in pediatric patients undergoing cardiothoracic surgery, in order to prevent surgical site infections (SSI) and minimize unintended effects of antimicrobial exposure. The guidelines incorporate evidence and recommendations from the literature below. Where pertinent literature or specific guidelines are lacking, prophylaxis recommendations were determined based on comparative practice with other pediatric heart centers and local consensus involving representatives from the CICU (RN and providers), Cardiac Surgery, Cardiology, the Antibiotic Stewardship Program, and Pediatric Pharmacy.

II. REFERENCES

The Society of Thoracic Surgeons Practice Guidelines Series: Antibiotic Prophylaxis in Cardiac Surgery, Part 1: Duration. Edwards FH, Engelman RM, Houck P, et al.; Society of Thoracic Surgeons. Ann Thorac Surg 2006 Jan; 81:397-404.

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Aortic Valve and Ascending Aorta Guidelines for Management and Quality Measures. Svensson LG, Adams DH, Bonor RO, et al. Ann Thorac Surg 2013;95:1491-505.

The Influence of Stents on Microbial Colonization of the Airway in Children After Slide Tracheoplasty: a 14-Year Single-Center Experience. Rijnberg FM, Butler CM, Speggiorin S, et al. Pediatr Pulmonol 2015;50:79-84.

Impact of Narrow vs. Broad-Spectrum Surgical Antibiotic Prophylaxis in Pediatric Patients with Enteral Tubes Undergoing Cardiac Surgery. Flett KB, Carpenter J, Potter-Bynoe G, et al. Open Forum Infect Dis 2017;4:S652.

Antibiotic Prophylaxis for Open Chest Management After Pediatric Cardiac Surgery. Hatachi T, Sofue T, Ito Y, et al. Pediatr Crit Care Med 2019;20:801-8.

III. POLICY

This guideline provides recommendations for perioperative antibiotic prophylaxis in pediatric patients undergoing cardiac surgery and should be adhered to whenever possible. The guidelines are not intended to replace clinical judgement. Modification of the prophylaxis regimen in individual circumstances may be warranted.

IV. PROCEDURES

A. Antibiotic selection should be made based on the type of cardiac procedure and the phase of care per **Table 1** below.

B. Antibiotic dosing should follow guidelines based on age and phase of care per **Table 2** below, or based on consultation with a pediatric clinical pharmacist.

C. For surgical procedures performed in the CICU, antibiotic prophylaxis should be selected as appropriate based on the pre-operative/intra-operative recommendation.

1. Even if the patient is already receiving antimicrobials for post-operative prophylaxis from another procedure, appropriate antibiotic prophylaxis should be re-dosed prior to a new procedure as in the OR. For example, if a patient undergoes chest closure in the unit, cefazolin should be given within 60 minutes prior to chest closure, unless the previous dose was given within the intra-operative re-dosing interval (4 hours).

D. The duration of prophylaxis should be limited to that recommended in **Table 1**, regardless of presence of lines or drains.

E. Modification of prophylaxis for patients with beta-lactam allergy or MRSA colonization:

1. For patients with beta-lactam antibiotic allergy, assessment is recommended per the Inpatient Beta-Lactam Allergy Guideline. Many patients with beta-lactam allergy can tolerate cefazolin, which provides more effective SSI prophylaxis than vancomycin.

2. For patients with history of methicillin-resistant *Staphylococcus aureus* (MRSA) infection or colonization, vancomycin should be added to the prophylaxis regimen. Vancomycin is administered as a prolonged infusion that should start 60-120 minutes prior to incision. Patients receiving vancomycin should also receive the standard prophylaxis agent for the procedure (usually cefazolin) unless they also have a beta-lactam allergy. Vancomycin alone provides less effective prophylaxis against SSI, and patients with prior MRSA may still develop SSI due to cefazolin-susceptible organisms.

3. Specific recommendations for patients with beta-lactam allergy or history of MRSA are included in the "routine" case rows in **Table 1**. For any of the remaining cardiac procedure categories where the patient has a documented beta-lactam allergy or known history of MRSA colonization or infection, the prophylaxis selection should be modified accordingly without beta-lactam prophylaxis for patients with documented beta-lactam allergy, and with addition of vancomycin for pre-operative and post-operative prophylaxis for patients with known history of MRSA.

Table 1: Antimicrobial Selection and Duration by Procedure Category

Cardiac Procedure Category	Pre-Op/Intra-Op Antimicrobial(s)	Post-Op Antimicrobial(s)	Post-Op Prophylaxis Duration
Routine case (not meeting any below exception criteria)	Cefazolin	Cefazolin	Until 24 hours post-op
Routine case with beta-lactam allergy	Vancomycin	Vancomycin	Until 24 hours post-op
Routine case with h/o MRSA infection or colonization	Cefazolin + Vancomycin	Cefazolin + Vancomycin	Until 24 hours post-op
Aortic root surgery, defined as aortic root replacement or reconstruction	Cefazolin + Vancomycin	Cefazolin + Vancomycin	Until 24 hours post-op
Presence of tracheostomy	Cefepime (+ Vancomycin if h/o MRSA)	Cefepime (+ Vancomycin if h/o MRSA)	Until 24 hours post-op
Open sternum	Cefazolin (+ Vancomycin if h/o MRSA)	Cefazolin + Vancomycin + Fluconazole	Until 24 hours post-chest closure
Sternum re-opened in CICU, sterility maintained	Cefazolin (+ Vancomycin if h/o MRSA)	Cefazolin + Vancomycin + Fluconazole	Until 24 hours post-chest closure
Sternum re-opened in CICU, sterility not maintained	Cefazolin (+ Vancomycin if h/o MRSA)	Cefepime + Vancomycin + Fluconazole	Until 24 hours post-chest closure or for 7 days if sternum remains open > 7 days If sternum remains open > 7 days, change to Vancomycin + Cefazolin + Fluconazole and continue until 24 hours post-chest closure
Slide tracheoplasty with open sternum post-op	Cefepime + Vancomycin	Cefepime + Vancomycin + Fluconazole	Until 24 hours post-chest closure, then continue Cefepime + Vancomycin until 7 days post-op
Slide tracheoplasty with closed sternum post-op	Cefepime + Vancomycin	Cefepime + Vancomycin	Until 7 days post-op
ECLS, peripheral cannulation, or placement of ventricular assist device	Cefazolin (+ Vancomycin if h/o MRSA)	Cefazolin (+ Vancomycin if h/o MRSA)	Until 24 hours following initial cannulation (or VAD placement) (prophylaxis should not be continued while cannulas in place)
ECLS, central cannulation, or placement of ventricular assist device, with open sternum	Cefazolin (+ Vancomycin if h/o MRSA)	Cefazolin + Vancomycin + Fluconazole	Until 24 hours post-chest closure
Rhythm management and monitoring device implantation without h/o MRSA or beta lactam allergy	Cefazolin	Cefazolin until able to take PO, then Cephalexin	Until 7 days post-op
Rhythm management and monitoring device implantation with beta-lactam allergy	Vancomycin	Vancomycin until able to take PO, then Trimethoprim-sulfamethoxazole (TMP-SMX)	Until 7 days post-op
Rhythm management and monitoring device implantation with h/o MRSA infection or colonization	Cefazolin + Vancomycin	Cefazolin + Vancomycin until able to take PO, then TMP-SMX	Until 7 days post-op

Table 2: Antimicrobial Dosing by Age and Phase of Care

		Cefazolin	Vancomycin	Cefepime	Fluconazole	Cephalexin	TMP-SMX
Intra-operative dosing							
Initial dose							
Usual dose		30 mg/kg	15 mg/kg	50 mg/kg			
Maximum		Usual Max: 2g Weight > 120kg: 3g	1g	2g			
Admin (may differ from usual floor admin)		IV push over 3-5 mins	60 min infusion	30 min infusion			
Timing of initial dose		0-60 min prior to incision	Infusion start 60-120 min prior to incision	Infusion start 30-60 min prior to incision			
Intra-operative re-dosing intervals[a]							
Pediatric Age > 1 mo[a]		q4h	q8h	q4h			
Neonate Age <=7d, OR Weight <=2kg		q6h	Do not re-dose	q8h			
Neonate Age >7d AND Weight > 2kg		q4h	Do not re-dose	q8h			
When to start standard dosing		After 3 doses convert to q8h	Already standard	After 3 doses convert to q8h			
Post-operative dosing							
Usual dose		25 mg/kg	15 mg/kg[b] Except: Neonate CGA <= 29 wk: 10 mg/kg	50 mg/kg	6 mg/kg	25 mg/kg	5 mg/kg TMP component
Maximum		1g	1g initial[b]	2g	400mg	500mg	320mg TMP component
Interval, Pediatric Age > 1 mo[a]		q8h	q8h[b]	q8h	q24h	TID	BID
Intervals, Neonate <= 1 mo; CGA = corrected gestational age; PNA = postnatal age							
CGA <= 29 wks	PNA 0-28 d	q12h	Consult pharmacist	q12h	q72h		
	PNA > 28 d	q8h			q48h		
CGA 30-36 wks	PNA 0-14 d	q12h	Consult pharmacist		q48h		
	PNA > 14 d	q8h	Consult pharmacist				
CGA 37-44 wks	PNA 0-7 d	q12h	q12h[b]			BID	
	PNA > 7 d	q8h	q12h[b]			TID	
CGA >= 45 wks		q8h	q8h[b]			TID	

[a] Dosing guidelines are provided for patients with normal renal function. Consult pharmacist for guidance on modification for impaired renal function.

[b] Monitor vancomycin trough before 4th dose, adjust regimen per clinical pharmacist recommendations.

F. Rationale for recommendations in **Table 1** including changes from previous guidelines:

1. Aortic root surgery prophylaxis recommendations have changed from vancomycin + piperacillin-tazobactam + fluconazole to vancomycin + cefazolin. The rationale is that the pathogens causing SSI in the setting of aortic root surgery are comparable to those that may cause SSI in patients undergoing routine cardiothoracic surgical procedures (primarily Gram-positive bacteria). Inclusion of vancomycin for prophylaxis in this procedure is based on local consensus to provide expanded coverage of MRSA given the increased potential for adverse consequences of SSI if it were to occur following an aortic root procedure.

2. Presence of tracheostomy remains an exception because of the higher rate of airway colonization with multi-drug resistant Gram-negative organisms observed in patients with a tracheostomy, and close proximity of the median sternotomy incision to the tracheostomy stoma. Vancomycin has been removed from routine prophylaxis in this category because MRSA colonization is not routinely observed in all patients with tracheostomy in place. Vancomycin should be administered to patients with known prior MRSA colonization or infection.

3. Open sternum antibiotic prophylaxis recommendations have been revised. There remain no published guidelines specifically addressing open chest antibiotic prophylaxis and little evidence to guide optimal prophylaxis. Practice variation exists with ~ 2/3 of pediatric cardiac centers in a comparative practice survey reporting use of narrow spectrum prophylaxis (cefazolin) and ~ 1/3 reporting some form of broader spectrum prophylaxis. The current recommendations are based on local consensus and review of microbiologic isolates in SSI cases.

4. Slide tracheoplasty is a clean-contaminated procedure involving incision into the intrathoracic trachea, with anticipated contamination of the mediastinum with tracheal flora. The procedure is performed for congenital tracheal stenosis and patients may come to surgery with prior airway colonization including multi-drug resistant organisms. Optimal antibiotic prophylaxis for this procedure is not well-defined, but in case series, *Staphylococcus aureus* and *Pseudomonas aeruginosa* are the most commonly described microbial isolates.

5. Recommendations for prophylaxis in patients placed on ECLS is based on recommendations from the ELSO Infectious Diseases Task Force, with modification of the central ECLS recommendation to be concordant with updated open chest guidelines.

6. Prophylaxis following pacemaker placement is based on local consensus. Published guidelines (ASHSP and AHA) recommend single dose antibiotic prophylaxis or up to 24 hours post-operative prophylaxis. These recommendations are based on data from adult patients. Currently data supporting short duration prophylaxis are lacking in pediatric patients. Of 9 pediatric institutions responding to a survey on duration of prophylaxis following pacemaker placement, 5 provide single dose or 24h post-operative prophylaxis, and 4 provide longer durations of prophylaxis (2-7 days).

7. Presence of GI ostomy or recent GI surgery has been removed as an exception to the routine prophylaxis recommendations based on a study by Flett, et al. finding no

difference in SSI rates or pathogen profile (equivalent rates of MSSA ~ 80% and Gram-negative rods ~ 20%) in patients with gastrostomy tubes vs. those without. The median sternotomy incision can be isolated from lower GI ostomy or surgical sites via draping and dressing procedures, and cefazolin provides activity against the most common enteric Gram-negative rods including *Escherichia coli* and *Klebsiella* species.

G. Further details of intra-operative surgical prophylaxis including re-dosing recommendations for blood loss can be found in the UCSF Antimicrobial Surgical Prophylaxis Guidelines.

V. RESPONSIBILITY

Questions about this policy should be directed to Satish Rajagopal, MD or Lori D. Fineman, RN MS.

VI. HISTORY OF POLICY

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