Harper Hospital
Detroit Medical Center/Wayne State University

9ICU/9WS
Cardiothoracic ICU/Cardiothoracic & Vascular Step-Down

Table of Contents

1. **Overview of the Units** ..... **Page 2**

2. **Anticoagulation Services**
   - Heart Valvle Repair & Replacement ..... **Page 3**
   - Heparin Dosing ..... **Page 3**
   - Warfarin Dosing ..... **Page 3**
   - Goal INR Ranges ..... **Page 4**

3. **Pharmacokinetics Services**
   - Surgical Prophylaxis ..... **Page 5**
   - Treatment of Endocarditis/Sternal Wound Infections ..... **Page 5**

4. **Thoracic Surgery**
   - Sterile Talc ..... **Page 5**
   - Streptokinase ..... **Page 5**

5. **Anticoagulation in Patients Undergoing CABG with Contraindication to Heparin**
   - Bivalrudin ..... **Page 6**
   - Argatroban ..... **Page 7**

6. **Nesiritide**
   - Review ..... **Page 9**
   - Criteria for Use ..... **Page 10**

Process Improvement Plan for 9ICU and 9WS

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Overview of the units

9ICU is primarily for patients s/p cardiac or thoracic surgery. Most patients underwent coronary artery bypass graft surgery (CABG), valve replacement, or lung resection. Additionally, 9ICU also serves as Cardiology Intensive Care Unit (CCU).

9WS is a step-down unit for Cardiothoracic, vascular and general surgery. Internal medicine and cardiology overflow patients are admitted when extra beds are available.

The CT Surgery residency program is a 3-year program, with 2 residents per year. CT Surgery services consist of cardiac and thoracic surgery. Each team has one of the residents from each class. The list of residents on each service is usually posted in 9ICU and 9WS. The 3rd year is considered a chief resident for either cardiac or thoracic surgery as assigned. They are responsible for all patients under their service but may be difficult to get hold of, since they are mostly in OR. The 2nd year residents are mainly responsible for patients in the ICU (9ICU) and the 1st year residents are responsible for patients in the step-down unit (9WS). Additionally, thoracic surgery usually has one additional resident from general surgery or emergency medicine.

Pager for contact persons

CT surgery residents

3rd yr:	(Chief)	Yang	7741
		Yamane	7032
2nd yr:	(9ICU)	Jumah	7473
		J Patel	7129
1st yr:	(9WS/5BC)	Khan	
		B Patel	

Cardiology fellows and residents

Cardiology fellow:	6666
Cardiology resident on call:	77777

Anticoagulation Services

Pharmacy is not always consulted for heparin or warfarin dosing. Please contact the primary team to verify whether to have anticoagulation service follow and define goal PTT and INR for each patient.

Heart Valve Repair and Replacement

Heart valve replacement is classified as bioprosthetic or mechanical valves. The most commonly used bioprosthetic valve is porcine valve (Hancock). St.Jude bileaflet valve is the most common mechanical valve used. Anticoagulation may be considered for patients with bioprosthetic valves for 3 months, but this is not always required. On the other hand, anticoagulation is indicated for all patients undergoing mechanical valve replacement. In general, valve replacement in mitral position has higher risk of thromboembolism in comparison with aortic position. In certain circumstances, mitral valve repair is done with annuloplasty ring, and anticoagulation may be indicated per the attending's decision.

Heparin Dosing

- For patients on intravenous heparin and scheduled for CT surgery, heparin should be discontinued 6 hours prior to surgery.
- Bolus dose of heparin is not recommended in post-operative patients.
- Infusion rate of heparin should be initiated conservatively at 12 units/kg/hr.
- In general, CT surgery is more conservative than other services with anticoagulation dosing due to the risks of post-op bleeding and hemothorax. Goal PTT for majority of the patients is 45-60 sec.
- For patients s/p mechanical valve replacement, heparin and warfarin may be started 48-72 hours after surgery or longer if the risks of bleeding remains significant. All anticoagulation should be initiated by the CTS residents or attending only. Warfarin may be started without IV heparin if patients are at high risk of bleeding.
- For patients with post-operative atrial fibrillation or flutter, heparin may be started after 48-72 hours if patients remain in atrial fibrillation/flutter. Again, some patients may be started on subcutaneous heparin only. IV heparin may be initiated when the bleeding risk is considered minimal (chest tubes and pacing wires have been removed). Patients should be on aspirin if platelet count is greater than 70.

Warfarin Dosing

- Loading dose of warfarin should be avoided in post-op patients. Consider initial dose of 2.5-5 mg only.
- Goal INR and duration of therapy should be discussed with CTS residents. Please refer to DMC Anticoagulation Dosing Guidelines for recommended goal INR for each indication.
- Goal INR for mitral valve repair with annuloplasty ring is usually 2-3 for the duration of 3 months.

Anticoagulation for bioprosthetic heart valve:

	Warfarin (INR 2-3)	Aspirin (80-100 mg)
First 3 months:		
AVR	+ (Grade 1C)	
MVR	+ (Grade 1C)	
After 3 months:		
AVR/MVR		+
AVR/MVR + risk factors*	+ (Grade 2C)	+

Anticoagulation for mechanical heart valve:

	Warfarin (INR 2-3)	Warfarin (INR 2.5-3.5)	Aspirin (80-100 mg)
AVR	+		
AVR + risk factors*		+	
MVR		+	
MVR (caged)		+	+
MVR + risk factors*		+	+
Duration: Life-long			

* Risk factors: atrial fibrillation/flutter, left atrial thrombus, previous thromboembolism

AVR: Aortic valve replacement

MVR: Mitral valve replacement

Pharmacokinetic Services

All patients on vancomycin and aminoglycosides should be automatically consulted for both 9ICU and 9WS.

Surgical Prophylaxis

- Cefazolin is the first line agent for both cardiac and thoracic surgery.
- For patients with penicillin allergy, vancomycin (±gentamicin) may be used. Vancomycin and gentamicin dose should be assessed in all patients for appropriate dosing for renal function.
- Duration of antibiotic should be only 24 hours after surgery. However, the antibiotic is usually continued until chest tube is removed in our clinical practice.
- If vancomycin or gentamicin is ordered for only few doses, a brief note may be written to indicate appropriate dose for patient's renal function. Dose adjustment may not be necessary if renal function is acceptable and no significant accumulation is expected after 2-3 doses.
- If the antimicrobial order is written for "until CT is discontinued" or duration is not indicated, the full initial note must be written per DMC Pharmacokinetic Dosing Policy for all vancomycin and aminoglycosides.
- When used for surgical prophylaxis, vancomycin criteria should be entered as "P7" and the duration should not be longer than 48 hours. Once the 48-hour window has passed, the resident and attending need to be contacted for discontinuation or attending override.

Treatment of endocarditis and sternal wound infection

- ID is usually consulted in all cases.
- When vancomycin is indicated for endocarditis or possible osteomyelitis, the trough levels should be maintained between 10-20 mcg/mL, rather than 5-15 mcg/mL.
- Outpatient arrangement for intravenous antibiotic use is extremely important since most patients require 6-week course for endocarditis and osteomyelitis. Please work closely with CRM and social worker for appropriate dosing and outpatient monitoring.

Thoracic Surgery

Sterile Talc

- Indicated as a sclerosing agent for intrapleural administration via chest tube for pleural effusions and pneumothorax
- Administer talc slurry through the chest tube by gently applying pressure to syringe plunger and empty contents of the syringe into chest cavity. After the talc slurry has been administered through the chest tube into the pleural cavity, the chest tube may be flushed with 10 to 25 milliliters of sodium chloride solution to ensure that the complete dose of talc is delivered.

Streptokinase

- May be used for pleural effusion to assist chest tube drainage
- Intrapleural dosage most commonly used is 250,000 International units in 100 milliliters Sodium chloride 0.9%. This dose has been administered as a single dose, or once or twice a day for 3 to 5 days. The dose is usually administered via a chest tube and retained in the pleural cavity for 2 to 4 hours by clamping the tube and then releasing the clamp and allowing the tube to drain.

Proposal for Anticoagulation in patients undergoing cardiopulmonary bypass with contraindications to heparin

Vasquez, Vichiendilokkul

Anticoagulant of Choice

Bivalirudin

Brand Name: Angiomax®

Manufacturer: The Medicine Company

Mechanism of Action

Bivalirudin is a reversible direct thrombin inhibitor. It can inactivate both soluble and clot-bound thrombin.

Pharmacokinetics

Bivalirudin is eliminated by a combination of renal mechanisms and proteolytic cleavage, with a half-life of 25 minutes in patients with normal renal function. Clearance was reduced approximately 20% in patients with moderate to severe renal dysfunction and was reduced by 80% in dialysis-dependent patients.

Approximately 25% of bivalirudin is removed by hemodialysis.

In *in vitro* studies, angiomax prolonged the activated partial thromboplastin time (aPTT), thrombin time (TT), prothrombin time (PT), and activated clotting time (ACT).

Adverse effects

Bleeding, back pain, nausea, headache, and hypotension.

Contraindications and Precautions

- Active major bleeding
- Hypersensitivity to bivalirudin or its component

There is no known antidote to bivalirudin. Bivalirudin is hemodialyzable.

Dosing Recommendation

- Pump Priming
  A bolus of 50 mg should be used to prime the CPB at the beginning of the procedure.
- Systemic Administration
  Initial bolus of 1.5 mg/kg, followed by a continuous infusion of 2.5 mg/kg/hr for the duration of the procedure, titrated to target ACT
- Dosage Titration
  Increase or decrease the infusion in 0.25 mg/kg/hr increments or to administer additional 0.25 mg/kg boluses to maintain target ACT.
- Discontinuation
  Angiomax should be continued throughout the procedure or until indicated by the surgeons.

Monitoring

Measure ACT at the following time points:

- Baseline
- 5 minutes after bolus dose of Angiomax
- 15-30 minutes after each dosage adjustment
- Every 30 minutes thereafter

Target ACT: 500-600 sec

Availability and Stability

Angiomax is available as 250-mg vial. The drug should be reconstituted in 5 mL sterile water, and further diluted in 50 mL of 5% Dextrose in Water or 0.9% Sodium Chloride.

Final concentration is 5 mg/mL. (e.g., 1 vial in 50 mL; 2 vials in 100 mL; 5 vials in 250 mL).

Reconstituted solution is stable at room temperature for up to 24 hours.

IV Compatibility

A dedicated line is recommended for administration, as compatibility information is limited.

Argatroban use for patients undergoing cardiac surgery

- Argatroban is a direct thrombin inhibitor indicated for the treatment of immune-mediated heparin-induced thrombocytopenia (HIT type II) with or without thrombosis.
- Argatroban is currently on the DMC formulary for treatment of HIT in patients with acute renal failure and those with end-stage renal disease requiring hemodialysis.

Pharmacokinetics

- Onset: 30 minutes
- Peak response: 2 hours
- Duration: 1-2 hours
- Half-life: 40-50 minutes
- Metabolism: Liver - require dose reduction in liver dysfunction (AST/ALT >3x UL)
- No dose adjustment in renal failure. Argatroban is not hemodialyzable.
- Argatroban prolongs aPTT, TT, PT/INR and ACT
- There is no known antidote to Argatroban.

Adverse effects

Bleeding, angina, fever and hypotension.

Contraindications and Precautions

- Active major bleeding
- Hypersensitivity to Argatroban

Dosing Recommendation

Off-pump:

- Initial bolus of 0.1 mg/kg, followed by a continuous infusion of 2.5 mcg/kg/min for the duration of the procedure, titrated to target ACT

On-pump:

- No pump priming

- Initial bolus of 0.1 mg/kg, followed by a continuous infusion of 5-10 mcg/kg/min for the duration of the procedure, titrated to target ACT

Dosage Titration:

Increase or decrease the infusion in 2.5 mcg/kg/min increments and/or to administer additional 0.05-0.1 mg/kg boluses to maintain target ACT

Discontinuation:

Argatroban should be continued throughout the procedure or until indicated by the surgeons.

Monitoring

Measure ACT at the following time points:

- Baseline
- 15-30 minutes after initiation and each dosage adjustment
- Every 30 minutes thereafter

Availability and Stability

- Argatroban is supplied as 250 mg in 0.9% NaCl or D5W 250 mL (final concentration of 1 mg/mL).
- Recommend a dedicated line for argatroban infusion since no compatibility data is available.
- The reconstituted solution is stable for 24 hours at room temperature.

Nesiritide Review

Pharmacology

- Recombinant human brain natriuretic peptide (hBNP)
- hBNP is secreted by ventricular myocardium in response to elevated ventricular filling pressure
- Decrease cardiac filling pressure via arterial and venous vasodilatation, natriuresis and diuresis
- Not an inotrope

Indication

- Treatment of acutely decompensated heart failure with dyspnea at rest or with minimal activity

Pharmacokinetics and pharmacodynamics

- Half-life: 18-22 minutes
- Onset: 15 minutes
- Eliminated by clearance receptors, intravascular proteolytic cleavage, and renal filtration

Efficacy

- Hemodynamic effects
  - i) ↓ PCWP, RAP, SVR and ↑ CI
  - ii) Significant decrease in PCWP within 15 minutes (vs. 2 hours with IV nitroglycerin)
- Clinical symptoms
  - i) Improve dyspnea and global clinical status within 3 hours
  - ii) Comparable to nitroglycerin and other standard care (dobutamine, nitroglycerin and milrinone)
- Diuresis
  - i) Increase urinary rate and urinary sodium excretion in clinical trials that withheld diuretics during nesiritide infusion
  - ii) No significant increase in urine output in clinical trials that allowed diuretic use during nesiritide infusion, but show a trend toward a decrease in diuretic use
- Mortality
  - i) Neutral effect on 6-month mortality

Adverse effects

- Hypotension (11%): comparable to IV nitroglycerin, but longer duration of hypotensive episodes
- Ventricular tachycardia: lower incidence than dobutamine
- Bradycardia
- Increase BUN and SCr

Contraindications

- Hypersensitivity
- Systolic BP <90 mmHg

Precautions

- Cardiogenic shock, low cardiac filling pressure and other conditions that cardiac output is dependent on venous return
- Not recommended to administer concomitantly with other vasodilating agents

Dosage and Administration

- 2 mcg/kg IV over 1 minute, follow by 0.01 mcg/kg/min continuous infusion
- If pulmonary artery catheter is placed, the dose can be increased by 0.005 mcg/kg/min with 1 mcg/kg bolus every 3 hours if SBP >100 or PCWP >20, with maximum of 0.03 mcg/kg/min
- If hypotension occurs, the infusion should be withheld until SBP >90. The drug can be resumed at 30% decreased infusion rate with no bolus.

Cost

- $380 for a 24-hr infusion in a 70-kg person

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Guidelines for the Use of Nesiritide (Natrecor®)

in Acutely Decompensated Heart Failure

Indication	Nesiritide is indicated for the treatment of patients with acutely decompensated chronic heart failure with dyspnea at rest or with minimal activity requiring IV therapy while on optimal dose of IV diuretic
DMC Restriction	1. Nesiritide can be prescribed by physicians in intensive care units, specific telemetry units (site-specific) and emergency/observation department ONLY. • SBP >90 mmHg on ICU/ED units • SBP >120 mmHg on telemetry units 2. Patients should receive optimal IV diuretics prior to nesiritide use.
DMC Guidelines*	1. Consider nesiritide in patients with the following conditions: a. Acutely decompensated CHF with dyspnea at rest or with minimal activity requiring IV therapy in addition to diuretics (NYHA Class III/IV) b. Elevated cardiac filling pressure by clinical exam, or PCWP >18 mmHg if pulmonary artery catheter in place c. Systolic blood pressure (SBP) >90 mmHg 2. No contraindication to vasodilating agents 3. Recommended duration of infusion: 24 to 48 hr 4. Not recommended for concomitant use with other IV vasodilating agents, including nitroglycerin, nitroprusside and milrinone 5. Pulmonary artery catheter should be considered if nesiritide is to be used as add-on therapy to inotropes (dopamine, dobutamine)
Contra-indications	1. Hypersensitivity to any of its component 2. SBP <90 mmHg 3. Avoid in patients with suspected low cardiac filling pressure, low cardiac output, cardiogenic shock, significant valvular stenosis, restrictive or obstructive cardiomyopathy, constrictive pericarditis, and pericardial tamponade
Reminder	Nesiritide is not a substitute for IV diuretics. To achieve optimal diuresis, diuretic use should be continued and dosage should be adjusted as necessary during concurrent nesiritide therapy.

* Consider consulting cardiology service during nesiritide use

Dosing recommendations

Initial bolus = 2 mcg/kg over one minute

Continuous infusion = 0.01 mcg/kg/min

Weight (kg)	Bolus dose (mL)	Infusion (mL/hr)	Weight (kg)	Bolus dose (mL)	Infusion (mL/hr)
55	18.3	5.5	85	28.3	8.5
60	20.0	6.0	90	30.0	9.0
65	21.7	6.5	95	31.7	9.5
70	23.3	7.0	100	33.3	10.0
75	25.0	7.5	105	35.0	10.5
80	26.7	8.0	110	36.7	11.0

Final nesiritide concentration = 1.5 mg/250 mL D5W (6 mcg/mL)

Recommended duration of infusion: 24 to 48 hr

PRE-INFUSION:

1. Baseline parameters are obtained and documented prior to administration of nesiritide
   a. Blood pressure; do not administer nesiritide if SBP <90 mmHg
   b. If pulmonary artery catheter is placed; PCWP, CO/CI and SVR should be monitored.
   c. Urine output
   d. Electrolytes and serum creatinine
2. IV diuretic therapy should be optimized prior to initiation of nesiritide and should be continued during nesiritide use.
3. Other IV vasodilating agents, including nitroglycerin, nitroprusside and milrinone, should not be used concomitantly with nesiritide

DURING INFUSION:

1. Monitoring during nesiritide therapy

- Blood pressure
- Improvement in hemodynamic parameters, including PCWP, CO/CI, SVR (if available)
- Improve in clinical symptoms
- Urine output, weight
- BUN/ Cr, electrolytes

IV diuretic should be adjusted as necessary during concurrent nesiritide therapy

2. Dose Titration above 0.01 mcg/kg/min

- Nesiritide dose may be increased, as necessary, every 3 hours if SBP ≥100 mmHg and PCWP ≥20 mmHg, or according to patient's clinical status
  ⇒ Administer an additional bolus of 1 mcg/kg and ↑ infusion rate by 0.005 mcg/kg/min
  ⇒ Maximum infusion rate = 0.03 mcg/kg/min
- Dose titration is NOT encouraged due to limited clinical experience

3. If hypotension occurs (SBP <80 mmHg or symptomatic hypotension)

- Hold nesiritide
- Start other measures to support BP: IV fluids, changes in body position
- Once patient is stabilized, restart nesiritide infusion at 30% reduced dose with no bolus

NURSING IMPLICATIONS

Drug Administration	1. Administer the bolus dose from the infusion bag 2. Infusion bag will be supplied as 1.5 mg in 250mL D5W (6 mcg/mL). 3. Infusion bag is stable at room temperature for 24 hrs
Blood pressure Monitoring	After initiation of therapy, blood pressure should be monitor at the following intervals: • At 15 minutes, 30 minutes, 1 hr after initiation of therapy • Every 1 hour for the first 3 hours • Every 3 hours thereafter
Compatibility Information	1. Nesiritide is incompatible with bumetanide, enalaprilat, ethacrynate sodium, **furosemide, heparin**, hydralazine, insulin and sodium metabisulfite (preservative in certain medications) 2. Recommend a dedicated line for nesiritide infusion 3. **Must NOT be administered through heparin-coated catheter**

Reviewed by: Cardiovascular and Thrombosis P&T Subcommittee, November 2001

Approved by: DMC P&T, January 2002

Prepared by: Anna Vichiendilokkul Pharm.D #00516, August 20, 2002