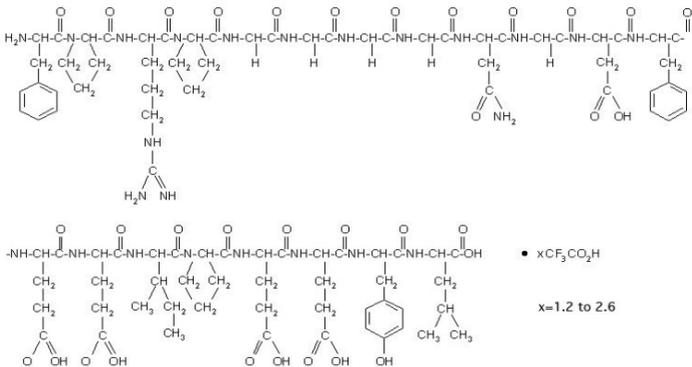




Figure 1: Structural formula for bivalirudin



Bivalirudin for injection is supplied as a sterile white lyophilized cake, in single-dose vials. Each vial contains 250 mg bivalirudin, equivalent to an average of 275 mg of bivalirudin trifluoroacetate\*, 125 mg mannitol, and sodium hydroxide to adjust the pH to 5-6 (equivalent of approximately 12.5 mg sodium). When reconstituted with Sterile Water for Injection, the product yields a clear to opalescent, colorless to slightly yellow solution, pH 5-6.

\* The range of bivalirudin trifluoroacetate is 266 to 284 mg based on a range of trifluoroacetic acid composition of 1.2 to 2.6 equivalents.

**12 CLINICAL PHARMACOLOGY**

**12.1 Mechanism of Action**

Bivalirudin directly inhibits thrombin by specifically binding both to the catalytic site and to the anion-binding exosite of circulating and clot-bound thrombin. Thrombin is a serine proteinase that plays a central role in the thrombotic process, acting to cleave fibrinogen into fibrin monomers and to activate Factor XIII to Factor XIIIa, allowing fibrin to develop a covalently cross-linked framework which stabilizes the thrombus; thrombin also activates Factors V and VIII, promoting further thrombin generation, and activates platelets, stimulating aggregation and granule release. The binding of bivalirudin to thrombin is reversible as thrombin slowly cleaves the bivalirudin-Arg<sub>3</sub>-Pro<sub>4</sub> bond, resulting in recovery of thrombin active site functions.

In *in vitro* studies, bivalirudin inhibited both soluble (free) and clot-bound thrombin, was not neutralized by products of the platelet release reaction, and prolonged the activated partial thromboplastin time (aPTT), thrombin time (TT), and prothrombin time (PT) of normal human plasma in a concentration-dependent manner. The clinical relevance of these findings is unknown.

**12.2 Pharmacodynamics**

In healthy volunteers and patients (with ≥70% vessel occlusion undergoing routine PTCA), bivalirudin exhibited dose- and concentration-dependent anticoagulant activity as evidenced by prolongation of the ACT, aPTT, PT, and TT. Intravenous administration of bivalirudin produces an immediate anticoagulant effect. Coagulation times return to baseline approximately 1 hour following cessation of bivalirudin administration. Bivalirudin also increases INR. Therefore INR measurements made in bivalirudin treated patients may not be useful for determining the appropriate dose of warfarin.

In 291 patients with ≥70% vessel occlusion undergoing routine PTCA, a positive correlation was observed between the dose of bivalirudin and the proportion of patients achieving ACT values of 300 sec or 350 sec. At a bivalirudin dose of 1 mg/kg IV bolus plus 2.5 mg/kg/h IV infusion for 4 hours, followed by 0.2 mg/kg/h, all patients reached maximal ACT values >300 sec.

**12.3 Pharmacokinetics**

Bivalirudin exhibits linear pharmacokinetics following IV administration to patients undergoing PTCA. In these patients, a mean steady state bivalirudin concentration of 12.3 ± 1.7 mcg/mL is achieved following an IV bolus of 1 mg/kg and a 4-hour 2.5 mg/kg/h IV infusion.

*Distribution*

Bivalirudin does not bind to plasma proteins (other than thrombin) or to red blood cells.

*Elimination*

Bivalirudin has a half-life of 25 minutes in PTCA patients with normal renal function. The total body clearance of bivalirudin in PTCA patients with normal renal function is 3.4 mL/min/kg.

*Metabolism*

Bivalirudin is metabolized by proteolytic cleavage.

*Excretion*

Bivalirudin undergoes glomerular filtration. Tubular secretion and tubular reabsorption are also implicated in the excretion of bivalirudin, although the extent is unknown.

*Specific Populations*

*Patients with Renal Impairment*

Total body clearance was similar for PTCA patients with normal renal function and with mild renal impairment. Clearance was reduced by 21% in patients with moderate and severe renal impairment with a half-life of 34 and 57 minutes, respectively. In dialysis patients, clearance was reduced by 70%, with a half-life of 3.5 hours. Approximately 25% bivalirudin is cleared by hemodialysis.

**13 NONCLINICAL TOXICOLOGY**

**13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility**

No long-term studies in animals have been performed to evaluate the carcinogenic potential of bivalirudin. Bivalirudin displayed no genotoxic potential in the *in vitro* bacterial cell reverse mutation assay (Ames test), the *in vitro* Chinese hamster ovary cell forward gene mutation test (CHO/HGPRT), the *in vitro* human lymphocyte chromosomal aberration assay, the *in vitro* rat hepatocyte unscheduled DNA synthesis (UDS) assay, and the *in vivo* rat micronucleus assay. Fertility and general reproductive performance in rats were unaffected by subcutaneous doses of bivalirudin up to 150 mg/kg/day, about 1.6 times the dose on a body surface area basis (mg/m<sup>2</sup>) of a 50 kg person given the maximum recommended dose of 15 mg/kg/day.

**14 CLINICAL STUDIES**

Bivalirudin Angioplasty Trial (BAT)

In the BAT studies, patients with unstable angina undergoing PCI were randomized 1:1 to a 1 mg/kg bolus of bivalirudin and then 2.5 mg/kg/h for four hours and then 0.2 mg/kg/h for 14-20 hours or to 175 IU/kg bolus of heparin followed by an 18-24 hour infusion of 15 IU/kg/h infusion. Additional heparin but not bivalirudin could be administered for ACT <350 seconds. The studies were designed to demonstrate the superiority of bivalirudin to heparin on the occurrence of any of the following during hospitalization up to seven days of death, MI, abrupt closure of dilated vessel, or clinical deterioration requiring revascularization or placement of an aortic balloon pump.

The 4312 subjects ranged in age from 29-90 (median 63) years. 68% were male, and 91% were Caucasian. Median weight was 80 kg (39-120 kg). 741 (17%) subjects had post-MI angina. Twenty-three percent of patients were treated with heparin within one hour prior to randomization.

The studies did not demonstrate that bivalirudin was statistically superior to heparin for reducing the risk of death, MI, abrupt closure of the dilated vessel, or clinical deterioration requiring revascularization or placement of an aortic balloon pump, but the occurrence of these events was similar in both treatment groups. Study outcomes are shown in Table 3.

Table 3: Incidences of In-hospital Endpoints in BAT Trial

Endpoint	BIVALIRUDIN (n=2161)	HEPARIN (n=2151)
Primary Endpoint <sup>1</sup>	7.9%	9.3%
Death, MI, revascularization	6.2%	7.9%
Death	0.2%	0.2%
MI	3.3%	4.2%

<sup>1</sup> A composite of death or MI or clinical deterioration of cardiac origin requiring revascularization or placement of an aortic balloon pump or angiographic evidence of abrupt vessel closure.

*AT-BAT Trial (NCT# 00043940)*

This was a single-arm open-label study in which 51 patients with heparin-induced thrombocytopenia (HIT) or heparin induced thrombocytopenia and thrombosis syndrome (HITTS) underwent PCI. The majority of patients achieved adequate ACT at the time of device activation and no major bleeding was reported. Evidence for the diagnosis of HIT/HITTS was based on a clinical history of a decrease of platelets in patients after heparin administration [new diagnosis or history of clinically suspected or objectively documented HIT/HITTS defined as either: 1) HIT: positive heparin-induced platelet aggregation (HIPA) or other functional assay where the platelet count has decreased to <100,000/mL (minimum 30% from prior to heparin), or has decreased to <150,000/mL (minimum 40% from prior to heparin), or has decreased as above within hours of receiving heparin in a patient with a recent, previous exposure to heparin; 2) HITTS: thrombocytopenia as above plus arterial or venous thrombosis diagnosed by physician examination/laboratory and/or appropriate imaging studies]. Patients ranged in age from 48 to 89 years (median 70); weight ranged from 42-123 kg (median 76); 50% were male and 50% were female. Bivalirudin was administered as either 1 mg/kg bolus followed by 2.5 mg/kg/h (high dose in 28 patients) or 0.75 mg/kg bolus followed by a 1.75 mg/kg/h infusion (lower dose in 25 patients) for up to 4 hours. Ninety-eight percent of patients received aspirin, 86% received clopidogrel and 19% received GPIIs.

The median ACT values at the time of device activation were 379 sec (high dose) and 317 sec (lower dose). Following the procedure, 48 of the 51 patients (94%) had TIMI grade 3 flow and stenosis <50%. One patient died during a bradycardic episode 46 hours after successful PCI, another patient required surgical revascularization, and one patient experienced no flow requiring a temporary intra-aortic balloon.

Two of the fifty-one patients with the diagnosis of HIT/HITTS developed thrombocytopenia after receiving bivalirudin and GPIIs.

**16 HOW SUPPLIED/STORAGE AND HANDLING**

**16.1 How Supplied**

Bivalirudin for Injection is supplied as follows:

NDC	Bivalirudin for Injection	Package Factor
71288-427-11	250 mg Single-Dose Vial	10 vials per carton

Bivalirudin for Injection is a lyophilized powder. Each vial contains 250 mg of bivalirudin equivalent to an average of 275 mg of bivalirudin trifluoroacetate\*.

\* The range of bivalirudin trifluoroacetate is 266 to 284 mg based on a range of trifluoroacetic acid composition of 1.2 to 2.6 equivalents.

**16.2 Storage**

**Storage Conditions**

Store at 20° to 25°C (68° to 77°F); excursions permitted between 15° to 30°C (59° to 86°F). [See USP Controlled Room Temperature.]

Discard unused portion.

**Sterile, Nonpyrogenic, Preservative-free.**

**The container closure is not made with natural rubber latex.**

**17 PATIENT COUNSELING INFORMATION**

Advise patients to watch carefully for any signs of bleeding or bruising and to report these to their health care provider when they occur.

 **meitheal.**  
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