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Best Practice:

Algorithms Replace Sliding Scale Insulin Orders

by Susanna Ku, Pharm.D.

Eighteen- to 34-year-old patients with diabetes have a 4x greater risk for hospitalization than similarly-aged patients without diabetes.[1] Although the origin of the practice is unclear, routine sliding scale insulin orders have long been a mainstay in the management of hospitalized patients with diabetes. Historically, the advantages of sliding scale insulin regimens included simplicity, convenience, and a reduction in calls to physicians when a patient's glucose levels were noted to be above the desired range.[2-5] With the commercial availability of new types of insulin, however, the practice is obsolete. Major problems with the continued use of sliding scale insulin in the general hospitalized (non-ICU) diabetic population include: 1) the practice is unsupported by controlled clinical trials, 2) the practice is at odds with the treatment goal of maintaining tight glycemic control, and 3) the practice fails to take into account interpatient variability in insulin sensitivity. The remainder of this article will address problems with prescribing sliding scale insulin regimens and suggest recommendations for improving practice.

The goals for glycemic control are less well established for hospitalized than for ambulatory patients; however, there are data to suggest that maintaining the blood glucose (BG) at 80–110mg/dL in critically ill patients reduces mortality.[6] In addition, hyperglycemia adversely affects wound healing and increases the risk of infection. Glycemic goals for hospitalized patients should approximate the ambulatory goals. For most hospitalized patients the goal fasting/preprandial blood glucose is 80–150mg/dL with the following important exceptions:

1) Patients with gastroparesis have unpredictable absorption of food, and thus it is difficult to achieve tight control without excessive risk of hypoglycemia;
2) Patients with retinopathy who are poorly controlled chronically can have acute progression of retinopathy if blood glucose is lowered too rapidly; and
3) Pregnant patients require tighter control to optimize fetal outcome.

Only one recent study has evaluated the efficacy of sliding scale insulin regimens. This study was conducted by Queale, et al. who assigned patients to a conservative, aggressive, or no sliding scale insulin regimen.[7] In the subset of patients who were not treated with any underlying glucose lowering medications, patients receiving either sliding scale regimen were three times more likely to experience hyperglycemia (>300mg/dL) than patients who were not started on sliding scale insulin therapy ($p<0.05$). The results of this study strengthen the argument that sliding scale insulin regimens have no place in the contemporary therapy of hospitalized patients with diabetes.

The sliding scale insulin method attempts to normalize elevated blood glucose levels by the administration of predetermined insulin doses. Problems associated with the sliding scale insulin method include a failure to take into account the patient's prehospital insulin regimen and a failure to recognize that preprandial, postprandial, and bedtime blood glucose goals differ.[8] Another criticism of this approach is that it retroactively manages blood glucose

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The origin of sliding scale insulin orders is not well understood. The practice likely evolved soon after regular insulin and urinary glucose monitoring became available.[12]

values rather than proactively maintaining the patient under optimal glycemic control. That is, as previously stated, instead of anticipating and avoiding blood glucose elevations, this approach runs counter to the goal of tight glycemic control.[2-5] Another criticism of the sliding scale insulin method is that it uses regular insulin. Given subcutaneously, regular insulin has an onset of 30–60 minutes and a peak effect in 2–4 hours. Thus, the cumulative effect of sliding scale insulin doses sets up the potential to overshoot the desired blood glucose goal and cause a cycle of fluctuating hypo- and hyperglycemia.[9] In contrast lispro and aspart insulins have an onset of 5–15 minutes and a peak effect in about one hour, making them superior to regular insulin for the correction of premeal hyperglycemia. Table I lists key characteristics of regular, lispro, and aspart insulins.

Table I: Comparison of Insulin Characteristics

Type of Insulin	Onset (minutes)	Peak (hours)	Duration (hours)	Lag Time* (BG within goal)
Regular	30 - 60	2 - 4	6 - 8	30 min
Lispro	5 - 15	1	3 - 5	5 - 15 min
Aspart	5 - 15	1	3 - 5	5 - 15 min

* Lag time is the length of time patients must wait between giving their prandial insulin and eating. A longer lag time is necessary when preprandial blood glucose is high.

Likewise, sliding scale insulin regimens fail to consider the individual patient's insulin sensitivity. For example, a septic patient with diabetes will have different insulin requirements than an otherwise healthy patient with diabetes admitted to the hospital with a fractured femur.[8] Clinically, the degree of insulin sensitivity can be estimated from the patient's total daily insulin dose. The awareness that insulin sensitivity is patient specific is the cornerstone for evolving best practice away from sliding scale regimens and towards insulin algorithms.

Recommendations for Improving Practice

Several factors need consideration when managing general hospitalized (non-ICU) patients with diabetes: 1) type of diabetes, 2) nutritional status, 3) risks for developing hyperglycemia, and 4) prehospitalized antihyperglycemic regimens.[8] Prescriber strategies that rely on sliding scale regular insulin regimens to control hyperglycemia should be avoided. Rather, basal and prandial insulin requirements should be supplemented with lispro or aspart insulin for premeal hyperglycemia according to the appropriate insulin algorithm shown in Table II. These algorithms are currently being introduced into practice at UWAMC.

It is important to note that insulin algorithms are not the same as conventional sliding scale insulin regimens. First, algorithms are used in addition to–*not as a replacement for*–proactive diabetes management with subcutaneous insulin and/or oral antihyperglycemic medications. Secondly, algorithm doses are based on the individual patient's premeal blood glucose, take into account the total daily insulin requirements, and are calculated according to the "1800 Rule." The "1800 Rule" estimates the reduction in blood glucose (in mg/dL) to be expected from each unit of insulin administered (see sidebar next page for calculation). For convenience, "1800 Rule" calculations have been grouped into three different "Insulin Algorithms" (see Table II) based on total daily insulin requirements ≤40units/day ("low dose"), 40-80units/day ("medium dose"), and >80units/day ("high dose"). Alternatively, the "1800 Rule" can be used to individualize insulin doses for patients.[11] Table III outlines additional recommendations that should be considered in the management of hospitalized (non-ICU) patients with diabetes. In addition, Figures 1 and 2 (see insert) illustrate general treatment flow diagrams for managing hospitalized patients with type 1 and type 2 diabetes mellitus.

Table II: Insulin Algorithms for Hyperglycemia[10]

Low Dose Algorithm (for patients requiring ≤ 40 units of insulin/day)	
Premeal BG	Additional Insulin
150-199	1 unit
200-249	2 units
250-299	3 units
300-349	4 units
>349	5 units

Medium Dose Algorithm (for patients requiring 40-80 units of insulin/day)	
Premeal BG	Additional Insulin
150-199	1 unit
200-246	3 units
250-299	5 units
300-349	7 units
>349	8 units

High Dose Algorithm (for patients requiring > 80 units of insulin/day)	
Premeal BG	Additional Insulin
150-199	2 units
200-249	4 units
250-299	7 units
300-349	10 units
>349	12 units

Individualized Dose Algorithm (dose calculated via the "1800 Rule")	
Premeal BG	Additional Insulin
150-199	
200-249	
250-299	
300-349	
>349	

(Text continues on page 53)

Figure 1: Flow Diagram for Treatment of Hospitalized (non-ICU) Patients with Type 1 Diabetes Mellitus[10]

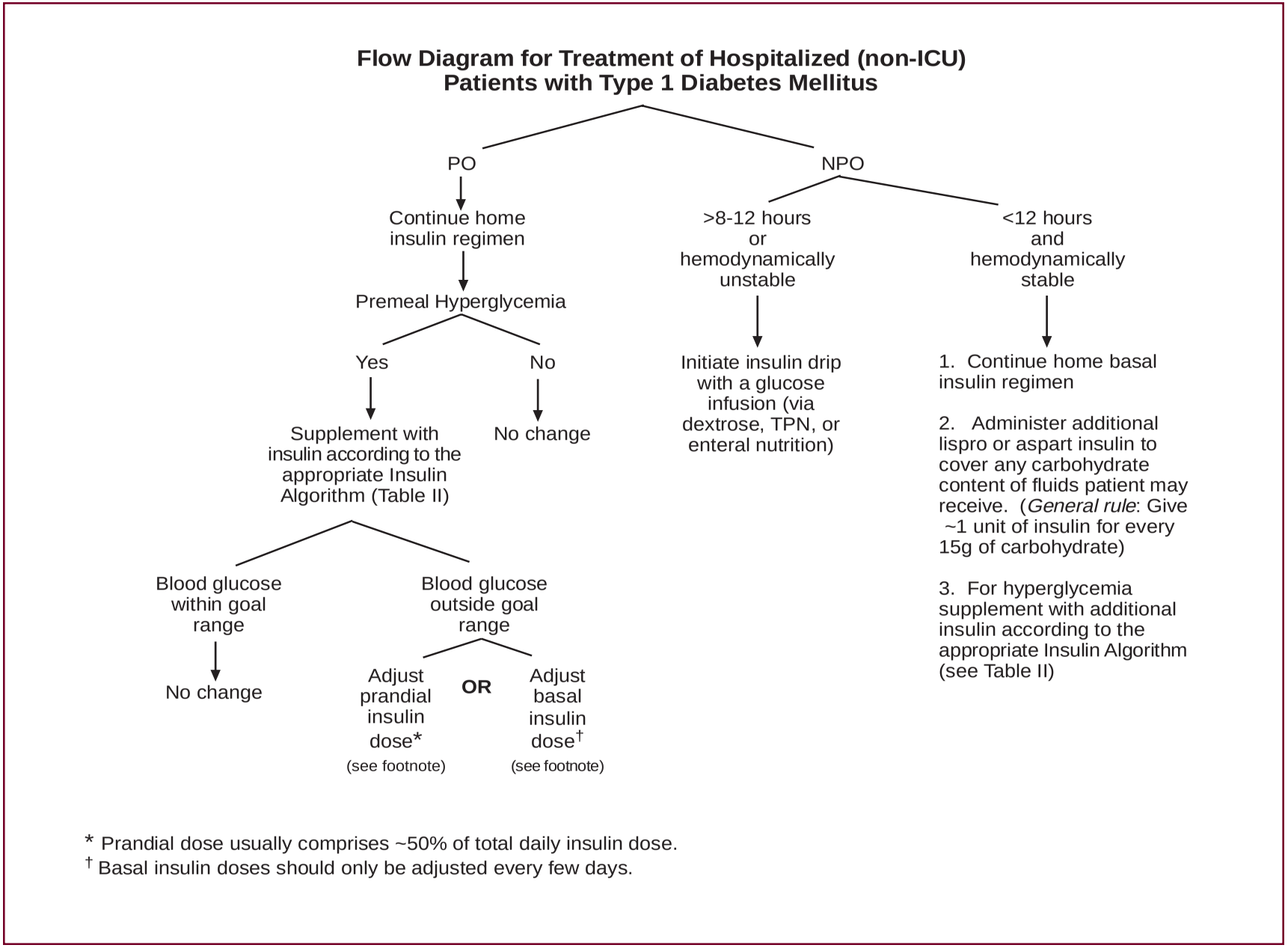
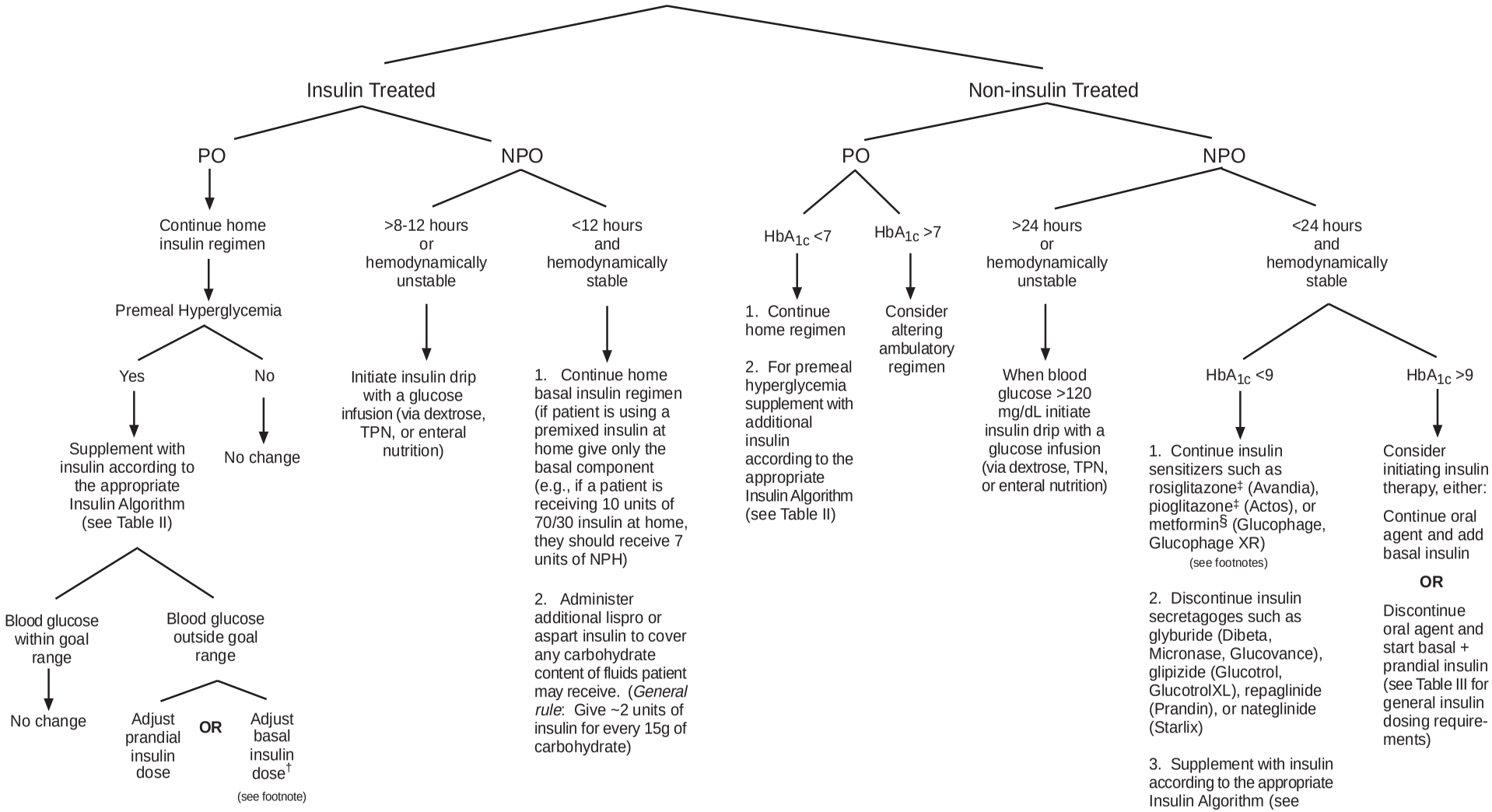


Figure 2: Flow Diagram for Treatment of Hospitalized (non-ICU) Patients with Type 2 Diabetes Mellitus[10]



† Basal insulin doses should only be adjusted every few days.

‡ Pioglitazone and rosiglitazone are contraindicated in patients with CHF, and thus should be discontinued in patients admitted with congestive heart failure.

§ Following any procedure which alters renal function, metformin needs to be held for 48 hours or until renal function returns to baseline.

Although previously a cornerstone of the management of hospitalized patients with diabetes, the use of sliding scale insulin regimens is no longer recommended.

The "1800" Rule

$$\frac{1800}{\text{total daily units of insulin}} = \text{mg/dL correction in BG to be expected from 1 unit of insulin}$$

As a general rule of thumb, patients with type 1 diabetes mellitus require 1 unit of insulin to cover 15gm of carbohydrate while patients with type 2 diabetes mellitus require 2 units of insulin to cover the same 15gm of carbohydrate.

In order to prevent ketosis and maintain target blood glucose readings, hospitalized patients with type 1 diabetes mellitus require the administration of insulin *even if they are not eating.*

Note: The editor gratefully acknowledges the assistance of Irl B. Hirsch, M.D., and Janet Kelly, Pharm.D., in preparing and reviewing this article.

Table III: General Recommendations in the Management of Hospitalized (non-ICU) Patients with Diabetes[10]

- The frequency of monitoring should be increased in the initial hospital course until patients stabilize and laboratory values normalize.
- The adjustment of patients' basal insulin more frequently than every few days should be avoided.
- General insulin dosing recommendations:

  Type 1 diabetes: (also see Figure 1)
  - ➢ Insulin must be present to prevent ketosis, even if patients are not eating.
  - ➢ Continue patients' prehospitalized basal insulin dose when admitting. Administer an insulin drip rather than subcutaneous insulin for patients who will be NPO or are hemodynamically unstable.
  - ➢ The prandial insulin (regular/lispro/aspart) needs to be adjusted based on the patients' clinical situation. Hospitalized patients are under metabolic stress (due to the release of stress hormones, the presence of infection, corticosteroid use, etc.) and generally require larger prandial insulin doses despite eating less.
  - ➢ The usual daily insulin requirement for patients with Type 1 diabetes is 0.5–0.7units/kg/day; however, newly diagnosed patients typically produce some insulin, and thus the initial daily insulin requirement is 0.3–0.5units/kg/day. (Note that approximately half the insulin requirement should be given as basal insulin and the remainder as prandial insulin.)

  Type 2 diabetes: (also see Figure 2)
  - ➢ If patient is using insulin at home, continue the outpatient regimen and adjust as needed.
  - ➢ If patient was not previously treated with insulin, but will need both prandial and basal insulin, start with a daily insulin requirement of 0.3units/kg/day. (Note that daily insulin requirements in Type 2 diabetes can exceed 1 unit/kg/day in some patients.)
- As a general rule of thumb patients with type 1 diabetes mellitus require one unit of insulin to cover 15 grams of carbohydrate while patients with type 2 diabetes mellitus require 2 units of insulin to cover the same 15 grams of carbohydrate.

Conclusion:

Although previously a cornerstone of clinical practice, the use of sliding scale insulin regimens in the management of hospitalized patients with diabetes is no longer recommended. This method of managing inpatients with diabetes is inconsistent with contemporary best practice. New insulin algorithms using insulin lispro or insulin aspart and based on the underlying degree of insulin sensitivity have replaced sliding scale regimens. Consistent with the goal to achieve tight glycemic control, the new insulin algorithms offer hospitalized (non-ICU) patients the best management option during times of metabolic stress.

References

1. www.niddk.nih.gov/health/diabetes/dia/chpt27.pdf. (Accessed Oct. 4, 2002)
2. Postgrad Med 1991;89:46-48, 51-54, 57.
3. Diabetes Care 2001;24(11):2011-2012.
4. Fam Prac Res J 1994;14:313-22.
5. Lancet 1997;349:1555.
6. N Engl J Med 2001;345(19):1359-67.
7. Arch Intern Med 1997;157:545-552.
8. Clin Diabetes 1994;12:40-42.
9. Med Clin North Am 1998;82(4):689-719.
10. Kelly, J. Personal communication, 10/1/02.
11. Post Grad Med 2002;111(5):51-66.
12. Arch Intern Med 1997;157(5):489.

Pharmacy & Therapeutics Committee Actions

Formulary Additions	Dosage Form(s), Strength(s), & Cost‡	Therapeutic Classification	Use	Usual Adult Starting Dose*
Brinzolamide (Azopt)	Ophthalmic suspension: 1% (5mL)-$8.14, (10mL)-$16.29	Carbonic anhydrase inhibitor	Primary open angle glaucoma and ocular hypertension	1 drop BID-TID
Fulvestrant (Faslodex)	Injection: 50mg/mL (2.5mL)-$306.80, (5mL)-$613.60	Estrogen receptor antagonist	Metastatic breast cancer in postmenopausal women	250mg IM at monthly intervals
Ipratropium bromide/ abuterol sulfate (DuoNeb)	Inhalation solution: 0.5mg/2.5mg (3mL)-$0.63	Anticholinergic/ bronchodilator	Moderate to severe COPD	Individualized
	Note: Added to the formulary resticted to outpatient use.			
Perflutren (Definity)	Injection: 2mL-$115.00	Diagnostic agent	Diagnostic echocardiograms	Individualized
Timolol/dorzolamide (Cosopt)	Ophthalmic solution: 0.5%/2% (5mL)-$28.00, (10mL)-$56.00	Beta-blocker/carbonic anhydrase inhibitor	Primary open angle glaucoma and ocular hypertension	1 drop BID
Voriconazole (Vfend)	Injection: 200mg-$85.00; Tablet: 50mg-$6.25, 200mg-$25.00	Triazole antifungal	Invasive/refractory systemic fungal infections	6m/kg IV Q 12h x 2 then 4mg/kg IV Q 12h
Formulary Deletions	**Dosage Form(s), Strength(s)**	**Therapeutic Classification**	**Use**	**Comment**
Dorzolamide (Trusopt)	All dosage forms and strengths	Carbonic anhydrase inhibitor	Primary open angle glaucoma and ocular hypertension	Replaced by brinzolamide
Albumin microspheres (Optison)	All dosage forms and strengths	Diagnostic agent	Diagnostic echocardiograms	Replaced by perflutren

* Refer to product labeling for full prescribing information. ‡ Costs represent UWMC/HMC outpatient acquisition costs and do not include pharmacy dispensing fees.

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DRUG INFORMATION CENTER
Box 354735
Seattle, WA 98195-4735

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