

Implementing a pharmacist-led transition of care model for posttransplant hyperglycemia

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Purpose. The implementation of a pharmacist-managed transition of care program for kidney transplant recipients with posttransplant hyperglycemia (PTHG) is described.

Methods. In September 2015, a collaborative practice agreement between pharmacists and transplant providers at an academic medical center for management of PTHG was developed. The goal of the pharmacist-run service was to reduce hospitalizations by providing care to patients in the acute phase of hyperglycemia while they transitioned back to their primary care provider or endocrinologist. For continuous quality improvement, preimplementation data were collected from August 2014 to August 2015 and compared to postimplementation data collected from August 2017 to August 2018. The primary endpoint was hospitalizations due to hyperglycemia within 90 days post transplantation. Secondary endpoints included emergency department (ED) visits due to hypoglycemia and the number of interventions performed, number of encounters completed, and number of ED visits or admissions for hypoglycemia. A Fisher's exact test was used to compare categorical data, and a Student *t* test was used to compare continuous data. A *P* value of <0.05 was considered to be statistically significant.

Results. Forty-three patients in the preimplementation group were compared to 35 patients in the postimplementation group. There was a significant reduction in hospitalizations due to hyperglycemia in the postimplementation versus the preimplementation group (9 vs 1, *P* < 0.05); there was a reduction in ED visits due to hyperglycemia (5 vs 0, *P* = 0.06). There were no ED visits or hospitalizations due to hypoglycemia in either group. Clinical transplant pharmacists performed an average of 8.3 (SD, 4.4) encounters per patient per 90 days.

Conclusion. A collaborative practice agreement was created and successfully implemented.

A pharmacist-managed PTHG program could be incorporated into the standard care of kidney transplant recipients to help minimize rehospitalizations due to hyperglycemia.

Keywords:

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Up to 90% of kidney transplant recipients (KTRs) can experience posttransplant hyperglycemia (PTHG).¹ This high incidence is attributable to both previously diagnosed and newly diagnosed diabetes. The development of PTHG within the first few weeks after transplant surgery has a strong association with the development of posttransplant diabetes mellitus (PTDM),² with 7% to 30% of nondiabetic KTRs developing PTDM in the first posttransplant year.³⁻⁴ Alternatively, many patients' hyperglycemia does not persist beyond the immediate posttransplant phase. Therefore, intensive glucose monitoring and management is necessary in the early period after a kidney transplant. In 2014, the Yale New Haven Transplant Center (YNHTC) observed a high frequency of rehospitalizations due to PTHG in KTRs before patients had been transitioned to a diabetes care provider. As a way to improve management of PTHG, YNHTC reviewed its current management of PTHG and developed a program to allow for improvement.

Background

The immediate posttransplant care of patients with PTHG can be a challenge. After kidney transplantation, patients experience various transplant-specific factors that increase their risk of developing PTHG. Induction therapy with high-dose glucocorticoids increases glucose transporter type 4 presentation on skeletal muscle, primarily impacting postprandial glucose storage while promoting catabolism of proteins, lipolysis, and gluconeogenesis.⁵ For maintenance immunosuppression, tacrolimus has various metabolic effects that predispose patients to diabetes, including reducing insulin secretion due to the destruction of pancreatic β -cell mass and increased islet apoptosis.⁶ Patients also undergo physiologic

changes. Patients with end-stage renal disease (ESRD) who have a glomerular filtration rate (GFR) that falls below 15 to 20 mL/min/1.73 m² have a notable decrease in insulin clearance. Hepatic insulin metabolism declines due to the accumulation of uremic toxins.⁷⁻⁸ After kidney transplantation, improvement in GFR (which may be unpredictable, especially in those with delayed graft function) eliminates many of these abnormalities, resulting in worsened control of preexisting diabetes or prediabetes. All these factors combined have a negative impact on glucose metabolism, resulting in a high incidence of PTHG.

Furthermore, initiation and monitoring of antihyperglycemic medications may lead to delayed discharges or readmissions due to inadequate monitoring or therapy.⁹⁻¹¹ Issues with transitions of care in the general population have been well established in the literature, including the need for improved communication between providers, patient education, and outpatient follow-up post discharge.¹² One in 3 adults may not see a physician, nurse practitioner, or physician assistant in 30 days following discharge. Additionally, patients who see a physician after discharge have a lower risk of rehospitalization.¹³ Although transplant providers will follow patients closely after discharge, involvement of other specialists and primary care providers remains warranted.¹⁴ In addition, posttransplant readmissions are costly and are associated with morbidity and mortality. A study showed that post-kidney transplant patients had a 6-fold increase in hospitalizations at 5 years compared to the general population.¹⁵ These hospitalizations, especially during the early posttransplant period, are associated with longer lengths of stay and greater hospitalization charges.¹⁶ Many studies have also suggested that posttransplant hospitalization costs sometimes exceed the cost of the transplant itself.¹⁷⁻¹⁸

The American Diabetes Association (ADA) recommends an outpatient follow-up visit with a primary care provider, endocrinologist, or diabetes educator within 1 month of

discharge if patients are stable and have hyperglycemia as an inpatient, or an appointment in 1 to 2 weeks if the antihyperglycemic regimen has been changed.¹⁹ This is a challenge, as patients with controlled diabetes or prediabetes may no longer be under the care of their previous endocrinologist or primary care provider. With increasing primary care physician workloads, physicians typically spend a small percentage of their time on diabetes care. One study reported that an average of 5 minutes is spent discussing diabetes management out of a 25-minute visit in a primary care clinic.²⁰ These challenges prevent the establishment of care in a time-effective manner and create a window where patients are at high risk for hyperglycemia and/or hypoglycemia, resulting in inadequate diabetes management and potentially poor outcomes.

YNHTC performs an average of 150 kidney transplants annually. YNHTC's immunosuppression protocol allows patients to receive induction therapy with rabbit antithymocyte globulin, alemtuzumab, or basiliximab, depending on sensitization and risk of rejection. Methylprednisolone is initiated at a dose of 500 mg on postoperative day 0, with rapid reduction of the glucocorticoid dose to 10 mg of prednisone by postoperative day 5. Patients remain on prednisone for life unless they are greater than 65 years of age with low sensitization. Other immunosuppression therapies include tacrolimus and mycophenolate mofetil. Prior to implementation of the pharmacist-managed PTHG program described here, transplant nephrologists and/or advanced-practice registered nurses were managing patients with PTHG until patients could be transitioned to the YNHTC endocrinologist, a primary care provider, or an outside endocrinologist.

In 2014, YNHTC identified that a clinical transplant pharmacist could be an appropriate resource to ensure adequate transitions of care during this high-risk period because they were an available resource already well integrated into both the inpatient and

outpatient transplant settings and able to provide continuity of care after hospital discharge. The purpose of this article is to describe our practice model and use of a collaborative practice agreement between transplant providers and pharmacists, including the planning, implementation, and quality assessment stages.

Methods

Collaborative drug therapy management program development. In September 2015, the clinical transplant pharmacists developed an outpatient collaborative drug therapy management (CDTM) program in collaboration with the transplant endocrinologist. The goal of the program was to allow for appropriate transitions of care until patients were able to see an endocrinologist or primary care provider. The CDTM program was approved by the institution-specific quality assurance and performance improvement committee and the pharmacy and therapeutics committee.

Clinical transplant pharmacists must have a doctor of pharmacy (PharmD) degree or equivalent experience and complete postgraduate residency training. As clinical transplant pharmacists are highly trained in both diabetes management and transplant pharmacy, they are ideally positioned to manage PTHG in KTRs.

Guidance was developed by following recommendations from a 2013 international consensus meeting on PTDM¹ and general recommendations for use of antihyperglycemic agents in type 2 diabetes outlined in the 2015 ADA standards of care.²¹ Which guideline the clinical transplant pharmacist followed depended on what antihyperglycemic agents patients were discharged on. If patients were discharged on an oral antihyperglycemic agent (or glucose monitoring), clinical transplant pharmacists followed the guidelines shown in Figure 1. If patients were discharged on insulin therapy, clinical transplant pharmacists

followed the guidelines shown in Figures 2 and 3. Combination therapy with both oral antihyperglycemic agents and insulin was allowed. If patients had type 1 diabetes, they received basal/bolus insulin therapy. Patients with insulin pumps were converted to basal/bolus therapy while inpatients and transitioned to an insulin pump as either inpatients or outpatients, and care was transferred directly to the endocrinology service. If clinical transplant pharmacists found that a patient's situation did not clinically fit within the guidelines, they could discuss interventions with the provider. Clinical interventions were reviewed at least monthly with the transplant providers. Noninsulin antihyperglycemic agents were limited to dipeptidyl peptidase-4 (DPP-4) inhibitors and sulfonylureas. Due to impaired or fluctuating GFR immediately post transplantation, biguanides (eg, metformin) were not recommended. Since many posttransplant patients experience postprandial hyperglycemia due to use of steroids, DPP-4 inhibitors are an ideal choice because they are oral medications whose use can result in postprandial glucose reductions, they pose a limited risk of hypoglycemia, and they have possible protective effects on beta islet cell function.²²⁻²⁴ Linagliptin was preferred over sitagliptin due to its lack of renal-dependent clearance. Sulfonylureas were used if patients were not controlled on DPP-4 inhibitors (Figure 1). Glipizide was preferred because it is metabolized by the liver into several inactive metabolites. As a result, although glipizide is renally cleared, dose adjustments are not required in patients with poor renal function.²⁵ Thiazolidinediones were not preferred due to the associated risks of weight gain, potential worsening of heart failure, and osteoporosis.²⁶ Sodium/glucose cotransporter 2 (SGLT-2) inhibitors were not indicated for use in the target population due to concern for increased risk of urinary tract infections and unstable GFRs immediately post transplantation and their limited use at the time of guideline implementation. Glucagon-like 1 (GLP-1) receptor agonists were not included in

the guidelines because there was limited data on their use in the posttransplant population at the time of implementation. Of note, the first version of the guideline (Figure 1) recommended use of sulfonylureas prior to DPP-4 inhibitors. However, the sequence was changed in January 2018, and DPP-4 inhibitors were preferred over sulfonylurea thereafter due to reasons mentioned previously.

Clinical transplant pharmacists and the transplant endocrinologist collaboratively reviewed any pertinent new literature and updated guideline recommendations annually, with the institution-specific guidelines updated accordingly. Guidelines were then presented to the YNHTC renal care quality assurance and performance initiative committee for final review and approval.

Insulin sliding scales were initially used to assess the requirements of a patient. For every 50-mg/dL increase in the insulin dose (starting at 150 mg/dL), an additional 1, 2, and 3 units were recommended for low-, medium-, and high-dose sliding scales, respectively. Clinical transplant pharmacists then followed ADA recommendations on starting basal insulin at a dosage of 0.1 to 0.2 unit/kg per day²¹ unless patients were significantly uncontrolled (blood glucose [BG] concentration of >250 mg/dL); in that case, clinical transplant pharmacists could start at a dose of 0.2 or 0.3 unit/kg per day. Sliding scales dictated prandial insulin starting doses. Nonmixed insulins were preferred over mixed insulins unless patients had difficulty injecting 3 times daily or required fewer injections (Figure 2). Clinical transplant pharmacists evaluated patients on a weekly to biweekly basis and adjusted insulin as indicated.

Patients who were on noninsulin antihyperglycemic agents were asked to determine their BG level once to twice daily, while those on insulin were asked to test 3 to 4 times daily. Patients were instructed to keep a BG diary to allow for efficient visits with the

pharmacy team. At each pharmacy visit, patients relayed their BG values, allowing for dose adjustments as indicated.

In patients with significantly elevated BG levels (>250 mg/dL), clinical transplant pharmacists screened for signs or symptoms of diabetic ketoacidosis (DKA) or hyperglycemic hyperosmolar syndrome (HHS) and escalated to the transplant coordinator, nephrologist, or endocrinologist, as indicated, for further evaluation and triage. Insulin doses were increased per protocol in patients who did not require referral to another provider. In patients with hypoglycemia, contributing factors were evaluated and changes to therapy were completed.

Patients were discontinued from antihyperglycemic therapy if clinical transplant pharmacists identified that the course of hyperglycemia was transient. In patients who were within the lower range of the goal BG value and required less than 20 units of insulin a day, weekly reductions were done to attempt to remove standing insulin and reassess insulin requirements based on a sliding scale. Insulin bolus doses were reduced prior to reduction of basal insulin unless patients were experiencing significant nocturnal or morning hypoglycemia. Depending on patient response, patients' insulin doses were uptitrated, they were transitioned to noninsulin therapies, or antihyperglycemic agents were discontinued. In patients who were within the goal BG range on oral antihyperglycemic agents, attempts were made to switch from multiple agents to a single agent or to discontinue single agents with close self-monitoring.

Implementation. The transplant pharmacy department is composed of 2 clinical intra-abdominal transplant pharmacist full-time equivalents. The intra-abdominal transplant pharmacists participated in both inpatient and outpatient responsibilities, including but not limited to inpatient rounds, order verification, therapeutic drug monitoring, and transplant listing clinic evaluation. The PTHG services were additional to current services. Pharmacy

residents and students rotated through the outpatient transplant rotation. All pharmacy personnel were allowed to assess patients telephonically or in person, but clinical transplant pharmacists were responsible for final decision-making.

Clinical transplant pharmacists optimized the capabilities of the electronic medical record (EMR) to allow for a dynamic list of patients followed for hyperglycemia. Within the list a “hand-off” column was created to allow easy identification of the earliest date of the next required intervention.

Since PTHG is dynamic and most KTRs are discharged on postoperative day 3 or 4, patients were manually screened for addition to the EMR list if their average BG level during inpatient admission was 150 mg/dL or higher. While patients were inpatients, most received sliding-scale insulin therapy, allowing for assessment of blood sugars at least 4 times daily, including assessment of fasting, preprandial, and nighttime values. The threshold of 150 mg/dL was chosen in accordance with the recommended upper goals for pre- and postprandial BG levels in the inpatient setting,²⁷ Providers could also refer patients who had elevated BG levels in the outpatient setting but were not already being followed by clinical transplant pharmacists.

Clinical transplant pharmacists discharged patients from the service once they were stable without use of antihyperglycemic agents, transitioned to a primary care provider, or transitioned to the transplant endocrinologist or pretransplant endocrinologist. Transition of care was defined as a patient’s establishment of care with a provider and successful completion of at least 1 visit. Additionally, providers could ask clinical transplant pharmacists to continue following patients until patients were more clinically stable. Interventions performed during provider visits focused on diabetes management, education, and counseling; referral to the transplant nutrition service, as needed; reminders

to establish or reestablish care with a primary care provider or pretransplant endocrinology; and referral to the transplant endocrinology service, as needed.

All interventions performed were documented with a standardized note template in the EMR within 24 hours.

Program evaluation. To assess the program and allow for continuous quality improvement, YNHTC performed a retrospective review of the service. This review was approved by the institutional review board at Yale New Haven Hospital.

Preimplementation data representing provider-based management were collected from August 2014 to August 2015; to allow for a 1-year period after approval and implementation of the program, postimplementation data were collected from August 2017 to August 2018. Patient data were collected for 90 days post transplantation. Patients were included if their average BG level during the transplant admission was 150 mg/dL or higher. Patients were included in the postimplementation group if they were followed by pharmacy services.

The primary endpoint was hospitalization with an admitting diagnosis of DKA, HHS, or hyperglycemia due to hyperglycemia within 90 days after transplant surgery. Secondary endpoints included ED visits due to hypoglycemia, number of interventions performed, type of interventions performed, number of encounters completed, and number of ED visits or admissions for hypoglycemia.

A Fisher's exact test was used to compare categorical data, and a Student *t* test was used to compare continuous data. A *P* value of <0.05 was considered to be statistically significant.

Results

During the preimplementation timeframe, there were 103 KTRs, and 43 of those patients met the inclusion criteria. In the intervention timeframe, there were 120 KTRs, and 47 patients met inclusion criteria. No patients received multiple kidney transplants during the timeframe. Eleven patients were not screened appropriately for follow-up by pharmacy services, and 1 patient was managed by insulin pump therapy and therefore was not followed by transplant pharmacy personnel. As a result, 35 patients were followed by clinical transplant pharmacists for PTHG management and were therefore included in the analysis (Figure 4). Baseline characteristics were similar in the pre- and postimplementation groups (Table 1).

There was a significant reduction in hospitalizations due to hyperglycemia in the postimplementation period versus the preimplementation period (1 vs 9 hospitalizations, $P < 0.05$); there was also a reduction in ED visits due to hyperglycemia (0 vs 5, $P = 0.06$). There were no episodes of admissions or ED visits due to hypoglycemia in either group.

Clinical transplant pharmacists had a mean (SD) of 8.3 (4.4) encounters per patient per 90 days. During these encounters, clinical transplant pharmacists performed a mean (SD) of 4.5 (3.2) interventions per patient per 90 days, compared to 1.2 (1.7) interventions per patient per 90 days in the preimplementation timeframe ($P < 0.01$). Characteristics of interventions made in the pre- and postimplementation groups are described in Table 2.

Discussion

Clinical transplant pharmacists have been continuously expanding their role in the inpatient and outpatient settings from improving medication adherence rates to participating in therapeutic drug monitoring.²⁸ Through an extensive literature review

around the time of writing, we identified 2 published articles on the use of pharmacists in posttransplant diabetes management. One article evaluated pharmacists' management of 25 adult KTRs with diabetes at discharge and found a significant (0.8%) mean reduction in glycated hemoglobin (HbA_{1c}) levels within 3 months in those who had a baseline HbA_{1c} value of $\geq 7.0\%$.²⁹ The other article, published by a group who established a clinic to manage PTDM in 33 adult transplant recipients, found a significant (1.6%) mean reduction in HbA_{1c} levels from baseline.³⁰ In keeping with these positive findings, we found a significant reduction in hospitalizations due to hyperglycemia. HbA_{1c} values were not collected in our study because clinical transplant pharmacist management in the posttransplant setting was expected to be transient.

Eleven patients were not appropriately screened for referral to clinical transplant pharmacist services for PTHG management, which might have been due to the lack of an automated screening process, the lack of a standardized referral process, and/or unfamiliarity with a new program. None of these 11 patients were rehospitalized for hyperglycemia. Nine of the 11 patients were not discharged on antihyperglycemic agents or BG self-monitoring, which might suggest that these patients had limited hyperglycemia and did not need follow-up by pharmacy services. We are currently working to improve this process through EMR optimization to avoid missed opportunities for pharmacist-led posttransplant diabetes management.

Our pre-post study had several limitations. The retrospective nature of the study limited data collection to information available in the EMR, thereby excluding interventions by out-of-network providers as well as hospitalizations or ED visits that may have occurred outside of the transplant center's health system. However, at our institution all KTRs are cared for by our transplant center in the first year post transplant surgery, ensuring a high

likelihood of data capture. Additionally, due to the retrospective nature of the review, self-monitored BG values around the time of a pharmacy encounter were not captured and reviewed. Since this review, we have improved our standardized note template to include documentation of these values.

Currently, pharmacists perform weekly patient follow-up to allow for timely dose adjustments of oral antihyperglycemic agents and insulin products and re-education when required. This can be a lengthy process, as each visit is scheduled for at least 15 minutes but can be longer depending on the complexity of the patient. Institutions may not have the available workforce for this intensive service. However, our institution believes that with the reduction in hospitalizations, the pharmacists' time spent is justifiable.

Conclusion

Implementation of clinical transplant pharmacist-led service to manage PTHG may result in a decrease in hospitalizations due to hyperglycemia.

Disclosures

The authors have declared no potential conflicts of interest.

Additional information

Dr. Do developed the project, researched data, and wrote the manuscript. Dr. Haakinson, Dr. Cohen, and Dr. Belfort De Aguiar developed the project, contributed to the discussion, and reviewed and/or edited the manuscript. Dr. Do is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Key Points

- The American Diabetes Association recommends that a primary care provider, diabetes educator, or endocrinologist should see a patient within 1 to 2 weeks post discharge if frequent hyperglycemic interventions are required.
- Posttransplant hyperglycemia (PTHG) has a high incidence and may persist after kidney transplant surgery. Due to the lability of PTHG, inadequate monitoring may result in unfavorable events such as rehospitalization.
- In a small sample of kidney transplant recipients, use of clinical transplant pharmacists to transition patients with PTHG to an endocrinologist or primary care provider was effective and reduced rehospitalization events significantly.

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Figure 1. Algorithm for initiation of outpatient oral antihyperglycemia agents. BG indicates blood glucose; FBG, fasting blood glucose; RBG, random blood glucose.

Figure 2. Algorithm for initiation of outpatient insulin management. BG indicates blood glucose; FBG, fasting blood glucose; RBG, random blood glucose.

Figure 3. Algorithm for outpatient insulin titration. BG indicates blood glucose.

Figure 4. Flowchart of patient sample formation.

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Table 1. Baseline Patient Characteristics by Study Group

	Provider-Managed (n = 43)	Pharmacist-Managed (n = 35)
Age, mean (SD), y	55 (12)	57 (9.5)
Male, No. (%)	27 (63)	25 (71)
BMI (kg/m ²), mean (SD)	27 (5.1)	30 (5.1)
Family history of diabetes, No. (%)	14 (33)	14 (40)
History of diabetes, No.(%)		
Type 1	8 (19)	5 (14)
Type 2	21 (49)	24 (69)
No history	14 (32)	6 (17)
Previous use of diabetes medications, No. (%)	21 (49)	18 (51)
Average blood glucose level during admission, mean (SD), mg/dL	185 (7)	190 (26)
Length of stay, mean (SD), d	7 (2.9)	5.8 (5.1)
Admission HbA _{1c} concentration, mean (SD), %	6.8 (1.8) ^a	7.0 (1.8) ^b
Maintenance steroids, No. (%)	34 (79)	31 (89)

Abbreviations: BMI, body mass index; HbA_{1c}, glycated hemoglobin;

^aValue is for the 34 patients who had a documented baseline HbA_{1c} level on admission.

^bAmong the 32 patients who had a documented baseline HbA_{1c} level on admission.

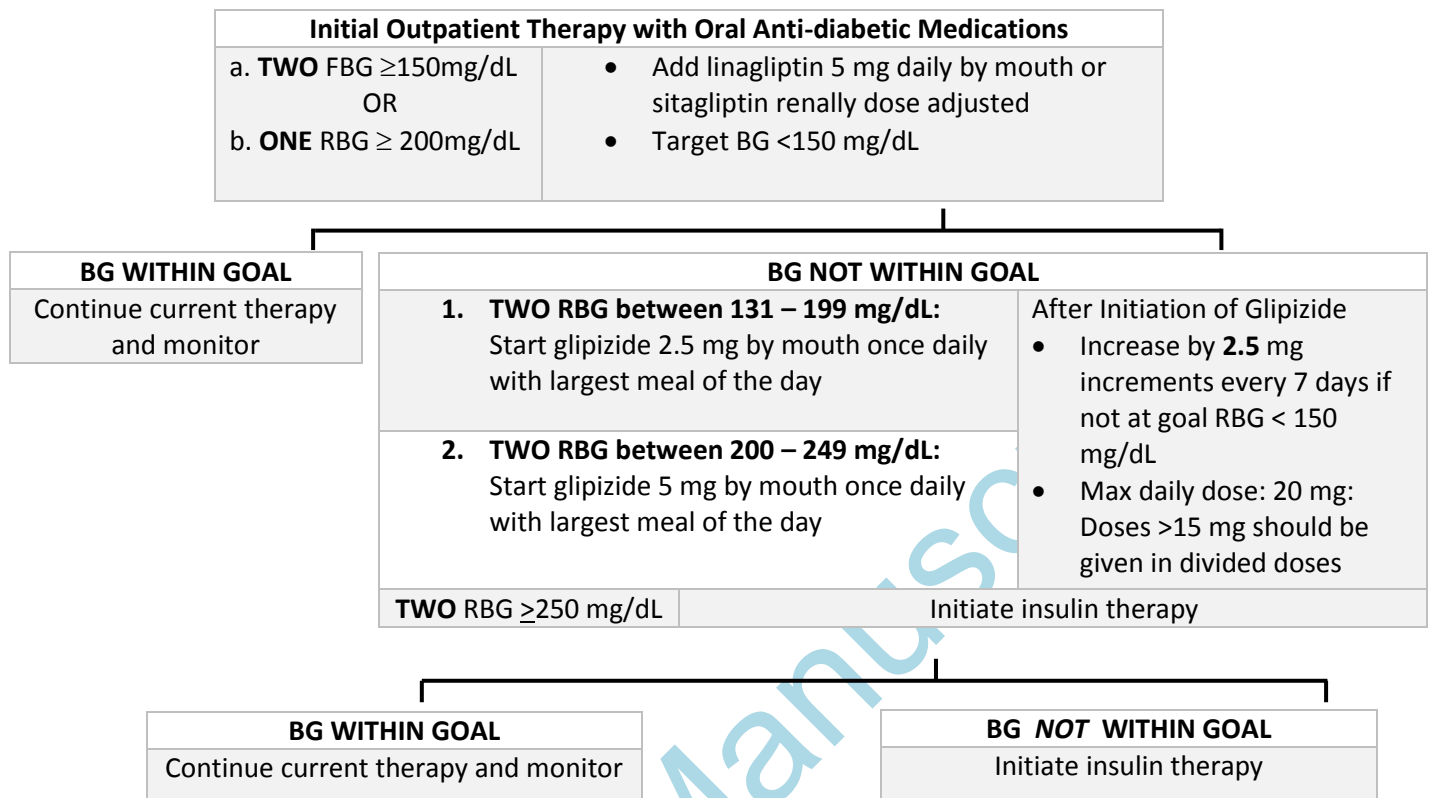
Table 2. Types of Interventions Performed, by Study Group^a

Intervention	Provider-Managed (n = 43)	Pharmacist-Managed (n = 35)
Add oral antihyperglycemic	3 (6)	5 (3)
Switch to oral antihyperglycemic	0 (0)	2 (1)
Adjust oral antihyperglycemic dosage	2 (4)	5 (3)
Discontinue oral antihyperglycemic	0 (0)	1 (1)
Add basal insulin	8 (15)	2 (1)
Discontinue basal insulin	0 (0)	3 (2)
Add bolus insulin therapy	9 (17)	10 (6)
Discontinue bolus insulin therapy	0 (0)	1 (1)
Adjust insulin dosage	31 (58)	130 (82)

^aAll data are number (percentage) of patients.

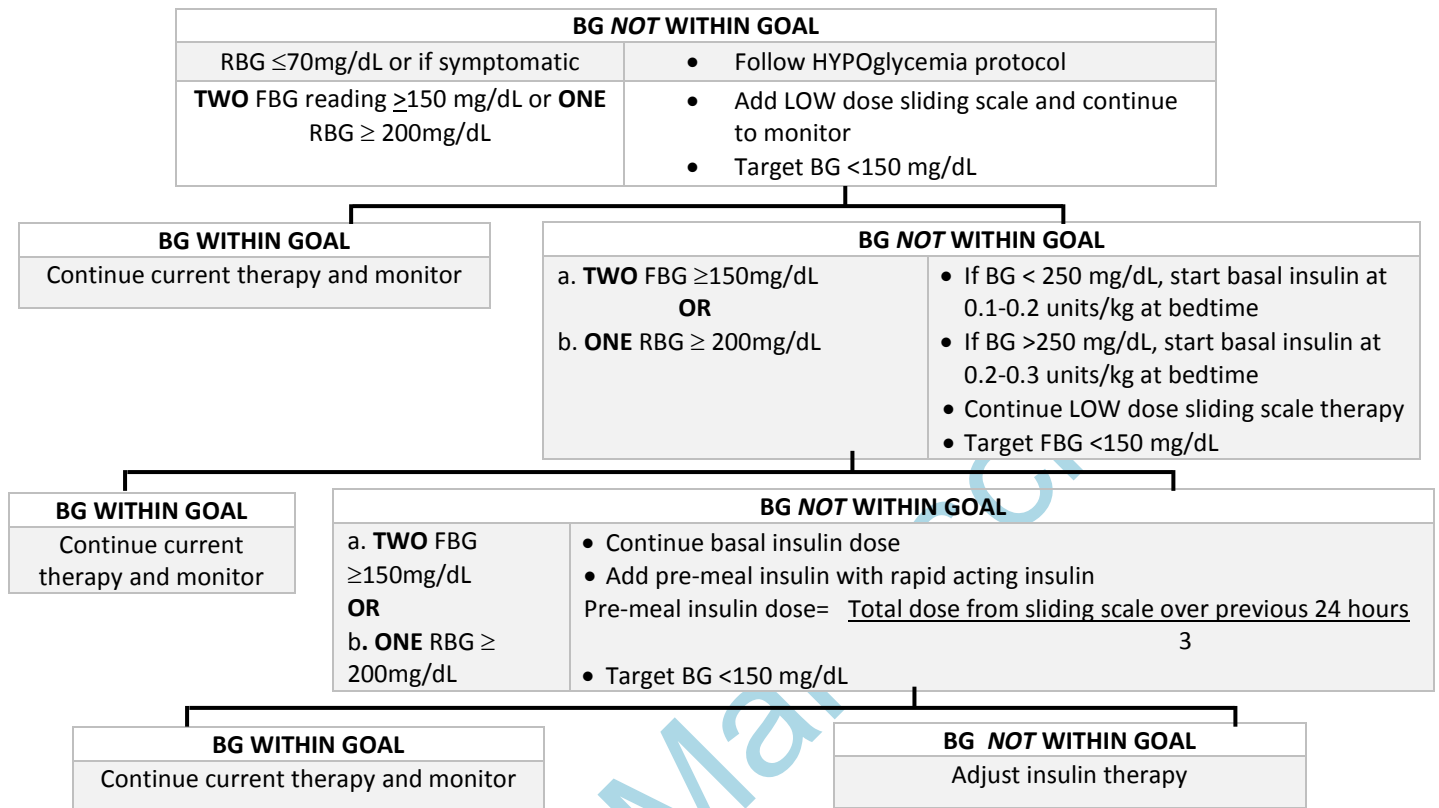
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Figure 1



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Figure 2



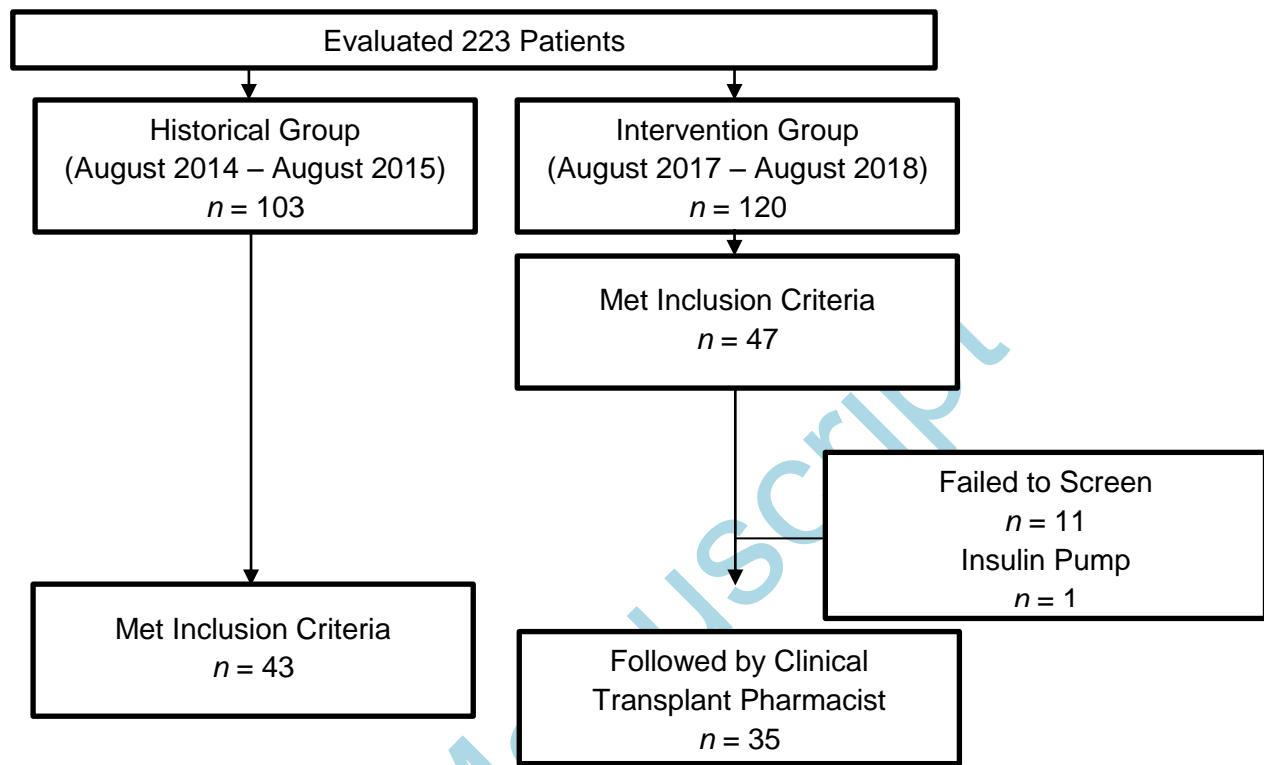
In patients unable to check BG three times daily or prefer/require less injections, mixed insulins (e.g. NPH/regular 70/30) may be used as a substitute.

To convert from a basal/bolus to mixed insulin: calculate total daily dose of insulin from all sources. Reduce dose by 10-20% if the patient is at high risk for hypoglycemia (patient is controlled). Divide the amount evenly into two doses.

Figure 3

Adjust accordingly if patient has TWO glucose levels not at target	
Fasting Blood Glucose	
BG (mg/dL)	Adjustment
<80	Decrease basal insulin dose by 15%
80-150	Continue current dose of insulin
151-200	Increase basal insulin dose by 10%
201-300	Increase basal insulin dose by 20%
300-450	Increase basal insulin dose by 20-30%
>450	Notify MD/provider
Pre-Prandial Blood Glucose	
BG (mg/dL)	Adjustment
150-200	Increase pre-meal insulin dose by 10%
200-300	Increase pre-meal insulin dose by 20%
300-450	Increase pre-meal insulin dose by 20-30%
>450	Notify MD/provider

Figure 4



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