

Ten Things Every Doctor of Optometry Should Know About Diabetes

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2 Hours

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Course Objectives

1. Attendees will learn the biology of diabetes, diabetes sub-types and the clinical requirements for diagnosis of both diabetes and pre-diabetes
2. Attendees will learn the key findings from the major prospective and epidemiological diabetes studies
3. Attendees will learn what questions optometrists should ask every patient with diabetes and pre-diabetes
4. Optometrists will learn unappreciated risk factors for diabetes and how to counsel patients about DM risk
5. A rationale for in-office laboratory testing for diabetes will be presented, including crystalline lens autofluorescence
6. Risk stratification for diabetes related eye disease will be presented along with a novel and validated on-line calculator for sight-threatening retinopathy

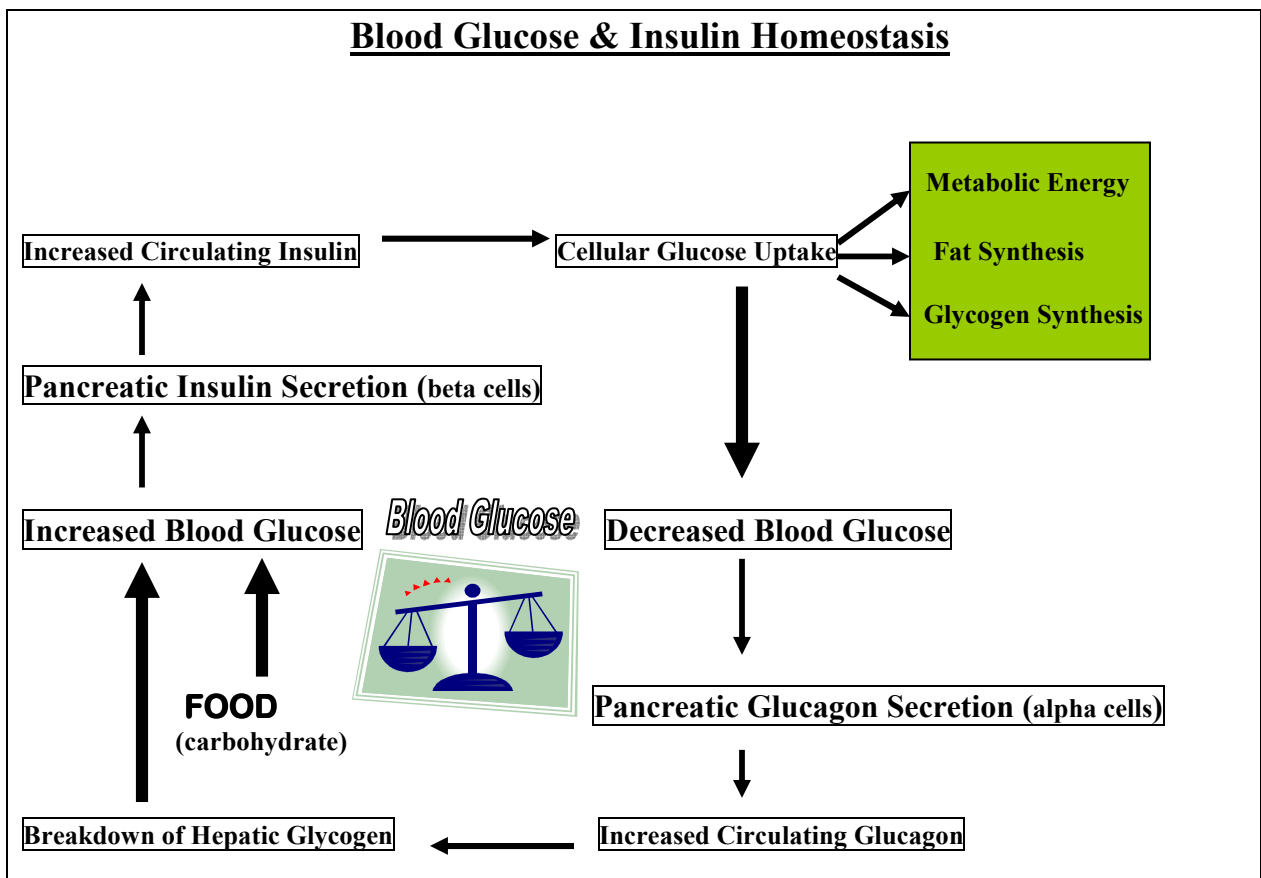
Every optometrist knows that diabetes has reached epidemic levels throughout the US and that diabetic retinopathy poses substantial risk of vision loss for those affected by the disease. We know, because we see these patients on a daily basis, because many if not most of these patients have poor understanding of their disease as well as suboptimal blood glucose control, because we witness all too frequently the bad outcomes associated with diabetes – amputation, renal disease, vision loss, coronary artery disease and stroke, to name a few of the most serious endpoints resulting from poor self care and/or inadequate treatment.

Because diabetes is such a complex disorder, patients are best served by a knowledgeable and caring team of health care professionals that communicates well and often with the patient, and with one another - a team that includes optometrists. In fact, doctors of optometry are ideally suited to care for and educate our patients with diabetes: we are trained to diagnose and manage the myriad ocular complications of diabetes and to recognize ocular and systemic symptomatology; we take care to listen to our patients; we take the time to thoroughly counsel; we see our patients regularly; we communicate quickly and effectively with other members of the health care team; we constantly strive to improve our knowledge and clinical skills.

It is for all of these reasons that Optometry has done an exemplary job treating patients with *glaucoma* and there are, it strikes me, many similarities between diabetes and glaucoma: both are chronic and “incurable;” both carry serious long-term risk of visual impairment; both are associated with clinical depression; both require active self-management and excellent patient education. In my view, if our experience with glaucoma is any measure, Optometry is ideally suited to care for patients with diabetes. Of course, most optometrists already know this but, for those who aren’t completely comfortable with diabetes, I’d like to offer some important pearls of wisdom, clinical commentary and suggestions for effective patient and physician communication.

(1) Know the basic biology of diabetes

All forms of diabetes mellitus involve derangement of normal blood glucose and insulin homeostasis¹ (the diagram below gives a general overview of glucose and insulin metabolism in a normally functioning individual). Insulin receptor defects (quantitative and/or qualitative) inhibit uptake of glucose by cells (type 2 diabetes). Beta cell failure results in inadequate circulating insulin levels (type 1 and type 2). Faulty inhibition of hepatic glycogen release may further promote hyperglycemia (type 2 diabetes).



Carbohydrate is broken down into the three simple sugars (glucose, fructose and galactose) that are absorbed by the small intestine. As blood glucose levels rise, pancreatic beta cells convert stored proinsulin molecules into insulin, which is then released directly into the hepatic portal vein. Circulating insulin binds to insulin receptors embedded in virtually all cells, allowing transport of glucose across cell membranes and subsequent reduction of blood glucose levels. When blood glucose levels fall too low, pancreatic alpha cells secrete glucagon to break down stored glycogen in the liver and release glucose into the bloodstream

(2) Know the diabetes sub-types and clinical requirements for diagnosis.

Type 1 diabetics have no (or rapidly waning) endogenous insulin production, require exogenous insulin, tend to be diagnosed before age 30, and are typically human leukocyte antigen (HLA) positive (i.e. type 1 diabetes is an autoimmune disease)².

Type 2 diabetics have at least some endogenous insulin production, tend to be insulin resistant, overweight or both, are usually diagnosed after age 30, and often require insulin as their disease progresses³. Remember that Type 2 diabetes in (especially overweight, under-active) children is becoming rampant⁴; the visual complaints associated with *Computer Vision Syndrome* may represent a mere fraction of the health cost being exacted by physical inactivity.

Gestational diabetes occurs during pregnancy as a result of decreased sensitivity to insulin. It typically remits after delivery, but women diagnosed with GDM have a 50% chance of developing type 2 disease within their lifetimes.

Diagnosis of diabetes² includes (a) fasting plasma glucose (FPG) ≥ 126 mg/dl on two occasions, or (b) random plasma glucose ≥ 200 mg/dl on two occasions with symptoms of polyuria (frequent urination), polydipsia (thirst) and/or weight loss, or (c) oral glucose tolerance test (OGTT - patient drinks a 75 gram loading dose of glucose) ≥ 200 mg/dl at 2 hours, or (d) HbA1c $\geq 6.5\%$

Prediabetes refers to blood glucose levels above normal but not reaching the threshold for diagnosis (FPG between 100 and 125 mg/dl and/or OGTT between 140 and 199 mg/dl at two hours and/or HbA1c $\geq 6.0\%$ but $< 6.5\%$). There are more than 79 million Americans with prediabetes and the majority of them will develop overt type 2 disease within ten years without intervention⁵.

Key Fact: type 1 patients have a higher percentage of complications, but type 2 patients suffer more complications because the latter outnumber the former by thirteen to one.⁶

Key Fact: Compared to type 1 patients, type 2 patients have a 22% higher risk of cardiovascular mortality per year¹.

Key Fact: One third of newly diagnosed patients between ages 10 and 20 have type 2 diabetes⁷.

Key Fact: New findings show that up to 8% of people with *prediabetes* manifest non-proliferative retinopathy, a fact that imperils the validity of current diagnostic criteria.^{8,9}

(3) Know the risk factors for developing diabetes

Risk factors for diabetes include both environmental and hereditary components. Type 2 diabetes occurs two to three times more frequently in Native, African, Hispanic and Pacific Island Americans, and has been linked to heritable mutations in mitochondrial DNA¹⁰. Central obesity is a major risk factor for developing insulin resistance, dyslipidemia and endothelial dysfunction that are characteristic of the so-called “metabolic syndrome” and type 2 diabetes.¹¹ Central obesity reflects the amount of visceral fat (fat surrounding the internal organs, or “visceral adipose tissue.”) Visceral fat promotes both insulin resistance and the mobilization of free fatty acids that are oxidized to cause vascular inflammation underlying much cardiovascular disease. Central obesity is defined as a waist circumference greater than 40 inches in males and greater than 35 inches in females.¹²

Type 1 diabetes has been linked to viral infection, bovine milk protein, gluten¹³ and, most recently, nitrate and nitrite preservatives¹⁴ (like those commonly used in luncheon meats) that may trigger beta cell destruction. The child of a parent with type 1 diabetes has roughly a 10% chance of developing the disease¹.

Key Fact: type 2 diabetes is strongly linked to sedentary lifestyle, abdominal obesity and family history. Essential hypertension, insufficient sleep, exposure to particulate air pollution and statin use are recently identified risk factors

Key Fact: type 1 diabetes is linked to one or several environmental “triggers” that activate beta cell auto-immunity or are directly toxic to those cells. More recently, T2DM has been linked to autoimmune influences

(4) Know the basics of the major diabetes studies

The **Diabetes Control and Complications Trial (DCCT)** studied 1441 type 1 patients over 10 years and found that “intensive diabetes management” (mean HbA1c = 7.2%) lowered the risk of developing diabetic retinopathy (DR) by 76% and the risk of worsening DR by 54% compared to “conventional diabetes management” (mean HbA1c = 9.0%); the risk of nephropathy and neuropathy were also significantly reduced.¹⁵ The **United Kingdom Prospective Diabetes Study (UKPDS)** followed 5000+ type 2 patients over 20 years and found that “intensive control” (mean HbA1c = 7.0%) resulted in a 25% decrease in all microvascular complications (retinopathy, nephropathy and neuropathy) and diabetes-related deaths compared to “conventional control” (mean HbA1c = 7.9%).³ The UKPDS also showed that tight control of hypertension (mean BP = 144/82) lowered the risk of severe vision loss by 49%, death due to diabetes by 32% and stroke by 44% compared to conventional control (mean BP = 154/87).¹⁶

The **Diabetes Prevention Program** showed that “lifestyle modification” (30 minutes of moderate physical activity like walking, five days per week) lowered the risk of developing type 2 diabetes in patients with prediabetes by 58% over a three-year period.¹⁷

Key Fact: Good blood glucose control definitely lowers the risk of diabetic retinopathy in both type 1 and type 2 diabetes. Meta-analysis of the DCCT and UKPDS shows that

each 10% reduction in HbA1c (e.g. from 8.0% to 7.2%) lowers the risk of DR progression by 43% - this linear relationship holds until HbA1c approaches 5%.

Key Fact: Based on UKPDS data, blood pressure control is equally or more important than blood glucose control in preventing eye disease and critical in lowering the risk of cardiovascular complications. A 10/5 mm reduction in blood pressure may literally mean the difference between life and death.

Key Fact: Prevention is the best medicine when it comes to diabetes and its myriad complications. Encourage your at-risk patients (by all means, encourage all your patients!) to engage in some consistent physical activity, 150 minutes each week.

(5) Ask about home blood glucose readings and glycosylated hemoglobin.

Virtually all people with diabetes should be performing daily (usually) multiple blood sugar measurements (*self-monitoring of blood glucose or SMBG*), as this guides self-management of diet, medication and physical activity.¹⁸ Recent evidence suggests that blood glucose variability, not just the blood glucose average, negatively affects both retinopathy and cardiovascular complications.¹⁹ Most home blood glucose meters calculate averages, standard deviations and graphically display test results via download to a personal computer. Good diabetes management is all about pattern management and, without data points, this task is impossible. Ask about post-prandial readings (2 hours after a meal), which should be under 150mg/dl (ask patients to bring their log book). Measurements immediately prior to your eye examination will help guide your refractive decision making and avoid prescribing during significant glycemic refractive fluctuations.

Glycosylated hemoglobin (HbA1c) reveals the mean plasma glucose over the preceding 60-90 days, the lifespan of red blood cells (like drawing blood every two minutes for 3 months and then averaging the results) and is the single best measure of overall glycemic control. The *American Association of Clinical Endocrinologists (AAACE)* recommends that HbA1c be less than 6.5%²⁰ (normal range is 4-6%). The relationship between mean plasma glucose and HbA1c can be easily determined: **Mean Plasma Glucose = 35.6(HbA1c) - 77.3**²¹ (e.g. an HbA1c of 6.5% yields a mean plasma glucose of $35.6 \times (6.5) - 77.3 = 154.1$ mg/dl). Several companies now make simple in-office HbA1c testing possible, but standardization has been problematic so values should always be compared against the “normal” laboratory reference range. A variety of hemoglobinopathies can yield false results, in which case plasma fructosamine (yielding a 2-3 week average) is sometimes used.

Key Fact: A recent survey shows that a mere 25% of patients with diabetes actually know their most recent HbA1c,²² whereas fewer than 50% perform SMBG on a daily basis.

Key Fact: Cardiovascular mortality risk rises linearly when HbA1c is above 4.8%²³

Key Fact: Each 10% reduction in HbA1c lowers the risk of diabetic retinopathy progression by an average of 43%.^{24,25} (it's so important, I said it again!)

(6) Measure their blood pressure & calculate retinal perfusion pressure

Recent evidence demonstrates that hyperglycemia increases blood flow into the eye by impairing retinal vascular auto-regulation. High retinal blood flow damages vascular endothelium, increases capillary permeability and promotes capillary non-perfusion, hallmarks of DRT. In type 1 patients especially, elevated retinal perfusion pressure (RPP > 50mm) strongly predicts development of sight threatening retinopathy. In type 2 patients, elevated mean arterial pressure (MAP > 97mm) raises the risk of sight-threatening retinopathy by up to six-fold.²⁶

$$RPP = 2/3 (MAP) - IOP \quad \text{where } MAP = (SBP - DBP)/3 + DBP$$

SBP = systolic blood pressure DBP = diastolic blood pressure
 MAP = mean arterial pressure IOP = intraocular pressure

Note that RPP rises (non-linearly) faster than blood pressure, making retinal micro-circulation especially susceptible to hypertensive insult.

Key Fact: Diabetic eyes cannot tolerate elevated blood pressure

Key Fact: Assuming a range of intraocular pressures 10 mm Hg or above, a blood pressure of less than 120/75 will significantly reduce the risk of developing sight-threatening diabetic retinopathy.

(7) Know the basic meds used to treat diabetes

There are a number of agents used to treat hyperglycemia, and knowing something about them helps eye care providers more intelligently discuss diabetes care with our patients and other physicians. Table 2 lists the current hypoglycemic agents used to treat diabetes.

Table 2 – Currently Available Pharmaceutical Agents For Diabetes²⁷			
Drug Class (used in)	Mechanism	Agents	Common Side Effects
Insulin (Type 1 & 2)	potentiates uptake of glucose by insulin-sensitive tissues (e.g.skeletal muscle)	Regular,NPH, Lente,Ultralente, Glargine (Lantus) Lispro (Humalog) Aspart (Novolog)	Hypoglycemia Weight gain
Sulfonylureas (Type 2 DM)	stimulate endogenous insulin release	Glyburide (Micronase) Glipizide (Glucotrol) Glimepride (Amaryl)	Hypoglycemia Weight gain
Biguanides (Type 2 DM)	improve peripheral insulin sensitivity and decrease hepatic glucose release	Metformin (Glucophage) Metformin ER (GlucophageXL)	GI upset

Thiazolidinediones (TZDs) (Type 2 DM)	improve peripheral insulin sensitivity	Pioglitazone (Actos) Rosiglitazone (Avandia)	Edema Weight gain
Non-sulfonylurea Secretagogues (T2DM)	stimulate endogenous insulin release	Nateglinide (Starlix) Repaglinide (Prandin)	Hypoglycemia Weight gain
Alpha-Glucosidase Inhibitors (T2DM)	slow intestinal absorption of carbs.	Acarbose (Precose) Miglitol (Glyset)	GI upset Flatulence
Amylin Analogs (Type 1 & 2)	slow gastric emptying; suppress post-prandial secretion of glucagon	Pramlintide (Symlin)	Nausea Hypoglycemia
GLP-1 Analogs (Type 2 DM)	stimulate brief insulin release, inhibit glucagon release & beta cell apoptosis, suppress appetite	Exenatide (Byetta) Liraglutide (Victoza)	Nausea
DPP-4 Inhibitors (Type 2 DM)	block the enzyme that breaks down endogenous GLP-1	Sitagliptin (Januvia) Saxagliptin (Onglyza)	
Combination Agents (Type 2 DM)	TZD plus biguanide sulfonylurea plus biguanide	Avandamet Glucovance	As for single agents

Type 1 patients lack the ability to produce their own insulin, so insulin replacement is a necessity via injection, subcutaneous infusion by an insulin pump or, most recently, inhalation (e.g. Exubera®, Pfizer). Pharmaceutical insulins are divided into long-acting (e.g. glargine, detmir and NPH), intermediate acting (lente and ultralente), short-acting (regular), and rapid acting (insulin aspart), with the aim of matching insulin bioavailability to food intake and physical activity. Insulin pumps (and now inhaled insulin devices) use only short and rapid acting insulins. Type 2 patients frequently benefit from insulin therapy, especially as their disease progresses; some experts believe early use of insulin may prolong survival of stressed pancreatic beta cells in patients with insulin resistance.²⁸

Oral agents used to treat hyperglycemia fall into four categories: drugs that increase production of endogenous insulin (sulfonylurea and non-sulfonylurea “secretagogues”); drugs that suppress the release of glucagon by the liver (metformin); drugs that increase peripheral insulin sensitivity (metformin and the thiazolidinediones); drugs that block the intestinal absorption of starch (alpha-glucosidase inhibitors). All of these oral agents are approved to treat type 2 diabetes only.

Two new classes of injectable drugs are now available for diabetes as well. The amylin analog, pramlintide mimics the action of the hormone amylin, which is secreted along with insulin by pancreatic beta cells.²⁹ Amylin moderates blood glucose spikes by blocking intestinal absorption, suppressing release of glucagon and appetite. The

glucagon-like peptide-1 (GLP-1) analogs mimic the action of gut hormones that stimulate brief insulin release only when food passes through the stomach. Exenatide, the first FDA-approved GLP-1 analog, is derived from a protein found in the saliva of the Gila monster (it's an exocrine protein that exerts endocrine effects – hence ex-en-atide) and is injected twice daily.³⁰ Both pramlintide and exenatide resulted in significant weight loss in clinical trials, a finding that sets them apart from every other agent currently used to treat diabetes. More recently, the GLP-1 analog, Liraglutide (Victoza) received FDA approval and requires single daily injection.

In addition to hypoglycemic agents, drugs that treat hypertension and dyslipidemia are a mainstay of diabetes therapy. As we have seen, more aggressive control of hypertension lowers the risk of retinopathy and cardiovascular complications. Both ACE inhibitors (e.g. lisinopril, enalapril) and ARB drugs (e.g. valsartan, losartan) have been shown to delay progression of diabetic kidney disease and, possibly, diabetic retinopathy.³¹ Statins (HMGCoA drugs) are now widely recommended for patients with diabetes because they not only lower LDL cholesterol, but appear to have a protective, anti-inflammatory effect irrespective of baseline lipid status.³² They are also associated with a 10% increased risk for developing T2DM. Aspirin therapy is also commonly used to combat the hypercoagulability (increased platelet adhesion) associated with diabetes.¹⁸

We all have heard patients proudly declare that “my diabetes is diet controlled!” Given that the mean HbA1c in the diabetic population is estimated to be somewhere between 8% and 9% (mean plasma glucose between 208 and 244 mg/dl), and that 80% of the 5,000 plus patients in the UKPDS eventually required the use of anti-diabetic medications (including insulin injections) to moderate dangerously high blood sugar levels, there is ample reason to be skeptical of such claims or, at least, use of the word “controlled.” Nonetheless, good dietary habits (carbohydrate restriction and, especially, portion control) and regular exercise are the foundation of any successful diabetes management plan. Even very modest weight loss often improves insulin sensitivity and blood sugar control by decreasing stores of visceral fat.¹¹

(8) Know and counsel patients about risk factors for diabetes complications

Diabetes is the leading cause of end-stage renal disease (ESRD) and non-traumatic amputation, the leading cause of severe visual impairment in Americans between ages 20 and 74, and the sixth leading cause of death in the US.⁸ In addition, people with diabetes face significantly higher risk of numerous other medical problems, including: GI and pancreatic cancer,³³ Alzheimer's disease³⁴ (the recent discovery of insulin producing cells within the brain itself and the loss of cerebral insulin production in Alzheimer's has led some investigators to label this disease “type 3 diabetes”)³⁵; restricted joint mobility due to advanced glycation of collagen; periodontal disease; depression; gastroparesis (delayed stomach emptying); erectile dysfunction; postural hypotension (the latter three conditions are classified as manifestations of *diabetic autonomic neuropathy*¹, a mechanism which probably also explains diminished pupillary responses in patients with diabetes).

The major risk factors for these complications include: disease duration, glycemic status, blood pressure status, blood lipid status, pregnancy. Other important risks include: cigarette smoking, lack of patient understanding, lack of familial/social support and lack of access to excellent care.

Key Fact: Eye complications of diabetes are often associated with neurological, kidney cardiovascular and joint disease.³⁶

Key Fact: Hyperglycemia accelerates the ageing process

Key Fact: Knowing the myriad complications of diabetes allows optometrists to better communicate, give better care and make appropriate referrals to PCPs and subspecialists

(9) Look for, manage and counsel patients about the ocular complications of diabetes, and how to prevent them.

Diabetes affects virtually every part of the eye.³⁷ Evaluate each patient for diabetic cranial neuropathy, diabetic keratopathy, cataract, premature vitreous degeneration, retinopathy (both diabetic and hypertensive), and optic nerve disease. Know the criteria for referral of proliferative retinopathy and diabetic macular edema “cold.” Let your patients know what you’re looking for and praise the absence of any of the above.

The diabetic retinopathy grading scale used in the *Early Treatment of Diabetic Retinopathy Study* (ETDRS)³⁸ has become the gold standard for clinical and scientific research, but has not been widely adopted by clinicians for a variety of reasons, including numerous sub-categories of disease and requisite comparison with standardized reference photographs. In an effort to create a more clinically useful system, a new classification scheme has been offered by an international panel of retinopathy experts.³⁹

International Clinical Diabetic Retinopathy (DR) Disease Severity Scale

No apparent DR	No ophthalmoscopically detectable retinopathy
Mild NPDR	Microaneurysms only
Moderate NPDR	More than “mild” but less than “severe”
Severe NPDR	≥ 20 intraretinal hemorrhages in all four quadrants; or definite venous beading in two or more quadrants; or prominent intraretinal microvascular abnormalities (IRMA) in one or more quadrants with no neovascularization
PDR	Definite neovascularization and/or vitreous or preretinal hemorrhage

ETDRS Criteria For Clinically Significant Macular Edema⁴⁰

1. retinal thickening involving the center of the macula
2. hard exudates within 500 microns of the center of the macula with associated retinal thickening
3. any area of retinal thickening > 1 DD in size, any part of which is within 1 DD of the center of the macula

Refer To a Retinal Sub-specialist when⁴¹

1. Any diabetic macular edema (DME)
2. Severe NPDR
3. Iris Neovascularization
4. Unexplained vision loss
5. PDR (stat referral if NVD > ¼ DD, or with any NVD or NVE accompanied by fresh vitreous hemorrhage)

Diabetic eye disease is common, especially with longstanding disease, poor blood glucose and blood pressure control, and lack of patient education. Emphasizing and reinforcing the connection between eye disease and systemic health goes, in my experience, a long way toward keeping our patients with diabetes both alive and seeing well.

Key Fact: In addition to retinopathy, diabetes substantially increases the risk of premature presbyopia and cataract, neovascular and primary open angle glaucoma⁴², dry eye and corneal disease⁴³ (including sensory neuropathy of cranial nerves V and VII), cranial nerve motor palsy (CNIII, IV, VI and VII), NAION and retinal vascular occlusion.⁴⁴

Key Fact: In combination with excellent blood glucose and blood pressure control, consistent follow-up by conscientious eye health care professionals greatly minimizes the risk and severity of diabetic eye disease and other complications.

(10) Communicate your findings and recommendations

Let the patient know that you are on her side, that you will promptly send reports to her other doctors, and that you will advocate for her in what patients often perceive to be a complex and confusing health care arena. Let the primary care physician, internist and endocrinologist know that you are able and willing to be an integral part of the diabetes health care team. Our ability and willingness to listen to our patients, counsel and communicate is one of Optometry's greatest assets.

AOA, several state optometric associations and many individual eye care practices have developed a standardized report form for diabetes related eye exams. In my view, all have merit because they streamline the communication process and make that communication much more likely to happen. I have included below the form I developed in consultation with the diabetologists and other health care providers with whom I have dialog. See

www.aoa.org/diabetes

Key Fact: All health care providers have the opportunity to “raise the bar” in diabetes care and education.

Key Fact: It's much easier to raise the bar together, when the patient and his/her health care team are on the same page and collaboratively pulling in the same direction.

Knowledge is Power

Knowledge is power, for both you and your patients. The on-line magazine Diabetes In Control (www.diabetesincontrol.com) tailors its contents to health care professionals

treating patients with diabetes and is replete with breaking research and clinical developments; the editors enthusiastically encourage optometrists to subscribe (its free). For patients, I highly recommend the books *Diabetes For Dummies* by Alan Rubin, MD and *Taking Control of Your Diabetes* by Steven Edelman, MD – both renowned diabetologists. My own book on diabetes (*Diabetic Eye Disease: Lessons From a Diabetic Eye Doctor*) is a great resource for patients interested in minimizing eye complications, and objectively/favorably depicts the important role played by optometrists in diabetes care, a role that is often disparaged or unappreciated in most books aimed at the lay public; I wrote it to be exactly the book I needed as a kid growing up with diabetes, and the book I want every one of my diabetic patients to have – because well-informed patients ask smarter questions, take better care of themselves, and help me do my job better.

Diabetes is a serious disease and represents a looming public health crisis. Optometrists are on the front line in this battle because we regularly see diabetic patients and are accustomed to comprehensively counseling all our patients. Knowing these “ten things” about diabetes and diabetes care will, I hope, help each of us better fulfill our role as primary health care providers. Doing so will not only save vision, but also lives.

Dr. Chous practices in Tacoma, WA with special emphasis on diabetic eye disease and diabetes education. He lectures and writes frequently on the subjects of diabetic eye disease and emerging treatments for diabetes and diabetic eye disease. He has had type 1 diabetes since 1968. He may be contacted at www.diabeticeyes.com

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CE Questions

- (1) Which of the following is false about blood glucose and insulin homeostasis?**
- blood glucose primarily rises in response to consumed carbohydrate and the breakdown of glycogen in the liver**
 - cells uptake glucose for metabolic energy, fat synthesis and glycogen synthesis**
 - insulin and glucagon are secreted by pancreatic beta cells**
 - insulin receptor defects block the cellular uptake of glucose in type 2 diabetes, leading to hyperglycemia**
- (2) Which of the following patients has diabetes per diagnostic criteria?**
- Fasting plasma glucose (FPG) of 128 mg/dl on one occasion**
 - Excessive thirst and frequent urination with a random plasma glucose of 180 mg/dl on two occasions**
 - An oral glucose tolerance test (OGTT) reading of 220 mg/dl at one hour**
 - An oral glucose tolerance test (OGTT) reading of 205 mg/dl at two hours**
- (3) Which of the following are risk factors for developing type 2 diabetes**
- Sedentary lifestyle**
 - Abdominal obesity**

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- c. Positive family history
 - d. All of the above

- (4) Which statement is FALSE about some of the major prospective diabetes studies?
- a. The DCCT and DPP both showed that intensive management of blood glucose lowers the risk of developing diabetic retinopathy
 - b. The UKPDS showed that a 10/5 mm reduction in blood pressure substantially lowers the risk of severe vision loss and stroke in type 2 diabetes
 - c. Glycemic control, as reflected by HbA1c percentage, was about 1% worse in the conventional group of the DCCT as compared to that of the UKPDS
 - d. The DPP showed that lifestyle modification to include 150 minutes of moderate physical activity each week lowered the risk of developing type 2 diabetes by almost 60% in patients with prediabetes over a three-year period
- (5) According to a recent survey, what percentage of patients with diabetes knows the results of their most recent glycosylated hemoglobin (HbA1c)?
- a. 18%
 - b. 25%
 - c. 35%
 - d. 45%
- (6) A patient has a glycosylated hemoglobin reading of 8.2%. Her mean plasma glucose over the last 8-12 weeks is:
- a. 142 mg/dl
 - b. 168 mg/dl
 - c. 192 mg/dl
 - d. 214 mg/dl
- (7) A patient with Type 2 DM has a mean blood pressure of 136/82. What is his mean arterial pressure (MAP), and is his risk of developing sight-threatening retinopathy substantially increased by this MAP?
- a. MAP = 100mm; Yes
 - b. MAP = 130mm; Yes
 - c. MAP = 100mm; No
 - d. not enough information to determine this
- (8) A patient with Type 1 DM has a mean blood pressure of 136/82 and a mean intraocular pressure of 20mm. What is her retinal perfusion pressure (RPP)?; is her risk of developing sight-threatening retinopathy substantially increased by this RPP?; what if her mean IOP is 10mm?

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- a. RPP = 100mm; Yes; RPP = 90mm and risk increases substantially
 - b. RPP = 46.6mm; No; RPP = 56.6mm and risk increases substantially
 - c. RPP = 46.6mm; Yes; RPP = 56.6mm and risk increases substantially
 - d. RPP = 46.6mm; No; RPP = 56.6mm and risk decreases substantially
- (9) Which of the following is not used to treat type 2 diabetes?
- a. metformin
 - b. exenatide
 - c. insulin
 - d. all are used to treat type 2 diabetes
- (10) Which statement about pharmaceutical agents for diabetes is FALSE?
- a. insulin is currently FDA approved for delivery by injection, by infusion from an insulin pump, or by an inhalation device
 - b. exenatide and TZDs are unique because they promote weight loss
 - c. angiotensin conversion enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) have been shown to delay the progression of diabetic nephropathy and may be of some benefit for diabetic retinopathy
 - d. metformin and TZDs both improve peripheral insulin sensitivity
- (11) Complications associated with diabetes include:
- a. increased risk of GI and pancreatic cancer
 - b. increased risk of Alzheimer's disease and depression
 - c. increased risk of gastroparesis, erectile dysfunction and postural hypotension
 - d. all of the above
- (12) Known risk factors for diabetes complications include all EXCEPT:
- a. poor blood glucose control
 - b. duration of diabetes
 - c. male gender
 - d. poorly controlled hypertension
- (13) Diabetes increases the risk for which ophthalmic complications?
- a. all those listed below
 - b. corneal disease and cranial nerve palsy
 - c. AION and retinal vascular occlusion
 - d. premature presbyopia and cataract
- (14) Which patient has "severe" non-proliferative diabetic retinopathy (NPDR) per the International Clinical Diabetic Retinopathy (DR) Disease Severity Scale?
- a. microaneurysms and intra-retinal hemorrhages in two quadrants
 - b. fresh vitreous hemorrhage obscuring the disc
 - c. definite venous beading and intra-retinal hemorrhages in two quadrants

d. all of the above have severe NPDR

- (15) According to AOA Clinical Practice Guidelines, diabetic patients should be referred promptly to a retinal specialist if they have:**
- a. evidence of fresh vitreous hemorrhage**
 - b. iris rubeosis**
 - c. any diabetic macular edema or unexplained vision loss**
 - d. any of the above**
- (16) Which patient has clinically significant macular edema per ETDRS guidelines?**
- a. hard exudates within 500 microns of the fovea with no retinal thickening**
 - b. retinal thickening without exudates in the center of the macula**
 - c. a 1.5 DD area of retinal thickening, the closest edge of which is 2 DD from the fovea**
 - d. none of the above constitutes CSME**
- (17) Which sub-populations have elevated risk of diabetes?**
- a. Asian and European Americans**
 - b. Hispanic, African, Native and Pacific Island Americans**
 - c. those who have abdominal obesity and a positive family history of DM**
 - d. b and c**
- (18) All of the following are true statements EXCEPT**
- a. Most patients in the UKPDS eventually required the use of hypoglycemic agents to control their blood glucose.**
 - b. SMBG gives patients and their doctors more data points to better manage their blood glucose patterns**
 - c. drugs like glyburide and glipizide rarely result in hypoglycemia**
 - d. measuring a patient's HbA1c says nothing about the variability of his or her blood glucose control during the preceding 2-3 months**
- (19) Diabetes is analogous to glaucoma because it:**
- a. requires good patient compliance with a treatment regimen**
 - b. poses serious threat of visual impairment**
 - c. requires frequent follow-up care and provider communication**
 - d. all of the above**
- (20) Which of the following patients has pre-diabetes?**
- a. fasting plasma glucose (FPG) of 140mg/dl on two occasions**
 - b. oral glucose tolerance test (OGTT) of 130mg/dl at 2 hours**
 - c. FPG of 110mg/dl on two occasions**
 - d. A random blood glucose measurement of 180mg/dl**

Answer Key: 1. c 2. d 3. d 4. a 5. b 6. d 7. a 8. b 9. d 10. b 11. d 12. c

13. a 14. c 15. d 16. b 17. d 18. c 19. d 20. c