Published in *Dancing in the Rain* in 2015 by Future Leaders (www.futureleaders.com.au)

When the Water Drops are Sweet: Living with Diabetes Mellitus

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About diabetes mellitus, blood sugar and the body

> There are five issues that make a fist of a hand that can knock America out cold. They're lack of jobs, obesity, diabetes, homelessness, and lack of good education. —Will. I. Am

The term *diabetes mellitus* is derived from Greek and Latin words meaning excessive discharge of urine (*diabetes*), which is honey sweet (*mellitus*). The disease diabetes mellitus was first described as early as 1500 BC by physicians from Egypt and India, who noticed the sweet or honey water in the urine of people with diabetes attracting ants.[1]

Since then, diabetes mellitus has become a global health challenge, affecting 382 million people in 2013. This number is expected to almost double to 592 million people by the year 2035. Most of this increase is due to an increase in type 2 diabetes, which contributes to the vast majority (85–95%) of all diagnoses of diabetes.[2] We will describe the different sorts of diabetes later in the chapter, but first we will define what diabetes mellitus is.

Diabetes mellitus can be defined as a group of chronic diseases characterised by high blood sugar levels. The high sugar levels are either caused by an inadequate amount of insulin produced by the body or an inability of the body to use insulin effectively. Insulin is

a chemical messenger or 'hormone' produced by special 'beta cells' in the pancreas. The pancreas is an organ located centrally in the abdomen, below the stomach and close to the small and large intestines. When food is digested from the stomach, food can be absorbed into the bloodstream as sugar. Insulin allows the sugar to be absorbed by the body's cells either for storage or for use as energy. For example, right now as you are reading this, insulin is allowing sugar to be absorbed into the muscle cells that move your eyes and hands so that your eyes turn as you read across the page and your hand can turn the page. Insulin also allows sugar to be absorbed into your brain cells so that you can think about and process what you are reading about diabetes.

There are two main types of diabetes, classified according to the body's problem with insulin — type 1 diabetes and type 2 diabetes.

In type 1 diabetes, the blood sugar levels become elevated because the pancreas is injured (see Table 1). Consequently, there is a lack of working beta cells to produce enough insulin to allow cells to take up the glucose in the blood. Most commonly, the pancreas is injured because the body's defence system (or immune system) attacks the beta cells — that is, the body's immune system attacks itself, and we say that the type 1 diabetes is 'autoimmune'. In other cases, we don't know what causes the pancreatic injury and we say that the type 1 diabetes is 'idiopathic'. Type 1 diabetes usually occurs in children or young adults. Less commonly it can occur in middle-aged adults and is described as late onset autoimmune type 1 diabetes of adults or latent autoimmune diabetes of adults (LADA). Type 1 diabetes is more common in people with a family history of type 1 diabetes and also people with other autoimmune diseases such as autoimmune thyroid disease or coeliac disease.

In type 2 diabetes, there are several major defects resulting in elevated blood sugar levels. We will discuss the two major ones. The first is a decreased ability of the body's cells to respond to insulin. This is called insulin resistance; the commonest factor contributing to insulin resistance is being overweight. The second defect is an

inability of pancreatic beta cells to produce enough insulin to overcome the insulin resistance. Type 2 diabetes usually occurs in middle-aged to older adults. It is more common in people who have a family history of type 2 diabetes, are overweight, are older, are of particular ethnic groups (for example, Indigenous Australian, Asian, Pacific Islander), have a sedentary lifestyle, have an unhealthy diet with a lot of fast food and sugar, or have diabetes during pregnancy (also called gestational diabetes).

Table 1
Features of type 1 and type 2 diabetes

	Type 1 diabetes	Type 2 diabetes
Age of onset	Children and young adults	Middle-aged adults
Risk factors	Family history, other autoimmune diseases	Family History, obesity, previous gestational diabetes, certain ethnicities (e.g. Indigenous Australian, Pacific Islander, Asian)
Cause	Destruction of pancreatic cells, resulting in an absolute lack of insulin in the body	Combination of (1) cells in the body being less responsive to insulin, and (2) a decreased ability of the pancreas to secrete insulin
Diabetic Keto-acidosis	Yes, often when first diagnosed, and especially if insulin is not administered	Generally no
Treatment	Always requires insulin Diet and lifestyle	Diet and lifestyle Tablets which lower glucose May require insulin

What happens when you develop diabetes?

> When I got married, I started needing to go to the toilet a lot to urinate. I was thinking, is this what happens when you get married? Then I discovered that I had diabetes. — Marie (her name has been changed for privacy)

When people develop symptoms due to type 1 diabetes, these are usually due to high blood sugar levels caused by the lack of insulin

in the body. High blood sugar levels usually cause people to feel thirsty, go to the toilet frequently to urinate, feel tired, lose weight, more easily develop infections, and to have blurry vision.

Type 1 diabetes can also cause a serious build-up of acid in the blood called ketones. Ketones are produced by the body when there is an inadequate amount of insulin to allow the cells to take up glucose and make energy. As the body needs energy, it starts breaking down fat for energy and this produces ketones (see Table 1). This condition is called diabetic ketoacidosis. Some people first discover that they have type 1 diabetes when they develop diabetic ketoacidosis. People with diabetes ketoacidosis may be very sick and have abdominal pain, nausea, vomiting, and even confusion. This condition may be life threatening. Treatment involves immediate attendance to hospital for emergency treatment — to give insulin and replace fluid through a drip in the vein.

In comparison, the onset of type 2 diabetes is often less dramatic and much slower. People may have type 2 diabetes for several years before they discover it. They can develop symptoms due to high sugar levels (for example, thirst, increasing need to pass urine). Sometimes, people discover that they have type 2 diabetes because they have symptoms from the complications of diabetes.

Having high blood sugar levels may cause inflammation in the lining of the blood vessels, resulting in the blood vessels becoming narrower. As blood vessels supply blood to all the organs of the body, many organs of the body can be affected, such as the heart, brain, kidneys, eyes and nerves.

When the blood vessels to the heart are affected, this can decrease blood flow to the heart, causing heart disease or a heart attack. A heart attack or myocardial infarction occurs when there is low blood flow to part of the heart due to a blocked blood vessel, causing part of the heart muscle to die. This causes development of sudden central chest pain, resembling a pressure or tightness on the chest. Often the pain radiates down the left arm or up the neck to the jaw and is associated with breathlessness. A

myocardial infarction is a life-threatening medical emergency. If suspected, an ambulance must be called to immediately bring the affected person to hospital to re-open the blocked vessel and prevent permanent damage to the heart. The quicker the blood vessel is re-opened, the less likely there is to be permanent damage.

Blockage of a blood vessel supplying the brain can cause a stroke, due to nerve damage in the brain from a lack of blood supply. The symptoms vary depending on the nerves affected. Typically if someone with diabetes suddenly develops arm or leg weakness; numbness on one side; difficulty speaking; or droopiness on one side of their face, then a stroke must be considered. Like a myocardial infarction, a stroke is a medical emergency. The faster an affected person can reach a hospital to have the blood vessel unblocked, the less likely permanent brain damage will occur.

Smaller blood vessels to the kidneys, eyes and nerves can also be affected, causing kidney disease, eye disease and nerve damage or neuropathy respectively.

Diabetes is the commonest cause of kidney failure and the commonest cause of need for dialysis treatment (which is like an artificial kidney where the body's wastes are removed from the blood) in Australia.[3] Diabetic kidney disease and diabetic eye disease often develop together. Consequently, if a person has kidney damage from diabetes they usually have eye damage due to diabetes as well. Early stages of diabetic kidney disease and diabetic eye disease are often asymptomatic. For example, early diabetic kidney disease may only be detected on a blood test looking at kidney function or a urine test showing protein in the urine. Both conditions only result in physical symptoms in very late stages, when the kidneys are close to failing, or when there is bleeding in the little vessels at the back of the eyes, causing loss of vision. It is therefore important to screen early for eye and kidney damage to allow treatment to prevent these complications from developing and progressing.

When people develop nerve damage to their feet, they can develop decreased sensation or altered sensation in their feet such as tingling, burning, or a feeling similar to ants crawling on their feet. Diabetic nerve damage in the feet may also contribute to foot complications such as foot ulcers, foot deformities, or even bone infections of the foot. Foot ulcers or bone infections of the foot are serious and may result in the person losing part of the foot.

Often when a person has diabetes, they also have other conditions that must be monitored, such as high blood pressure and high cholesterol. All these other conditions increase the person's risk of having heart attacks, strokes or kidney damage.

Symptoms of diabetes

- Thirstiness
- Urination
- Loss of weight
- Tiredness / lack of energy
- Increased skin infections
- Diabetic ketoacidosis (type 1 diabetes).

Complications of diabetes

- Ischemic heart disease (narrowing of the vessels to the heart)
- Stroke (blockage of the vessels to the brain)
- Peripheral vascular disease (narrowing and blockage of the vessels to the legs and feet)
- Diabetic nephropathy (diabetic kidney disease)
- Diabetic retinopathy (diabetic eye disease)
- Peripheral neuropathy (nerve damage due to diabetes)
- Diabetic foot complications (ulcers, bone infection, foot deformity).

Managing diabetes is a lifetime proactive team sport

> I have high blood sugars, and type 2 diabetes is not going to kill me. But I just have to eat right, and exercise, and lose weight, and watch what I eat, and I will be fine for the rest of my life. — Tom Hanks

> I do not love to work out, but if I stick to exercising every day and put the right things in my mouth, then my diabetes just stays in check. — Halle Berry

Managing diabetes in most cases is a lifetime proactive team sport. It is lifetime, because it is a chronic disease and is not going to disappear. It is a team sport, because managing diabetes is a partnership and combined effort between the person with diabetes, the person's family, and the health professionals caring for the person. Each team member plays a vital role in the successful management of diabetes. This is especially the case for the person with diabetes, who benefits greatly from taking the leading role as the team captain. This is recognised by many people who have been managing their diabetes for some time.

> I think patient responsibility is a big thing … until we come to the point of wanting to make a difference and do something about our condition, then all the education and all the talking from the doctor will just go over our heads. — Tom (name changed for privacy)

Management of diabetes is also proactive. We often tell our patients that if they don't deliberately take control of their diabetes, diabetes will eventually take control of their lives through long-term diabetic complications.

Managing diabetes is best viewed as managing cardiovascular disease, or disease of the blood vessels and heart. By managing cardiovascular disease, complications related to narrowing of the vessels can be prevented and minimised (for example, kidney disease or heart disease). As mentioned previously, diabetes is often associated with high blood pressure, high blood cholesterol levels and being overweight, all of which increase the risk of cardiovascular disease. All these conditions need to be managed simultaneously by medications and a healthy lifestyle and diet. Similarly, given that smoking also contributes to cardiovascular disease, people who smoke must stop or get the help required to stop.

The cornerstone of diabetes management is a healthy diet, regular exercise and weight loss, if overweight. A healthy diet is one that has carbohydrates from fruits, vegetables, and low-fat dairy products, but is limited in meat, fried and fatty foods, sweets, refined grains, and sweet drinks such as juice. It is important that a consistent amount of food and carbohydrates is eaten every day and that meals are not skipped, to minimise the risk of having low sugar levels due to treatment with glucose-lowering medications. Recommended regular exercise is at least half an hour of exercise on most days of the week and can include walking, gardening or playing a sport. Weight loss is also important if the person with diabetes is overweight. As a general principle, a person can lose weight by eating less and moving more. Even weight loss of 5 to 10% of your current weight is beneficial for improving blood pressure, blood sugar and cholesterol levels.

Apart from diet and exercise, glucose-lowering medications are also important for controlling blood sugar levels. Good control of blood sugar levels will minimise damage to blood vessels and minimise complications such as kidney disease or heart disease. There are various medications used in type 1 and type 2 diabetes (see Table 2). People with type 1 diabetes require insulin because their bodies do not produce enough. Without insulin they are at risk of developing diabetic ketoacidosis. For type 2 diabetes, metformin is usually the first treatment used, followed by other medications, generally added in a cumulative fashion. If the blood sugar level cannot be controlled with tablets, insulin may be needed.

Monitoring blood sugar levels is important for guiding treatment. There are two ways people with diabetes have their blood sugar levels assessed. The first is the glycated haemoglobin (HbA1c) blood test, which measures the extent of blood sugar control over the preceding three months. The second is by patients measuring their own blood glucose levels using a blood glucose monitor or a glucometer. This gives an indication of the person's day-to-day blood sugar levels, and involves a finger prick using a lancet, and measuring the blood glucose from the blood droplet via a glucometer. This is

referred to as self or home blood glucose monitoring (HBGM). The amount of monitoring a person does, and the target blood sugar levels that are aimed for, varies depending on the person's situation. Generally, the recommendation is to aim for a glycated haemoglobin test of less than 7% and a blood sugar level before meals of 5–7 mmol/L and less than 10 mmol/L two hours after meals, to minimise the risk of long-term complications.[4] Depending on the person's situation, the target HbA1c and HBGM levels may be higher or lower.

A potential complication of glucose-lowering treatment is having a lower than normal blood sugar level (<4 mmol/L) or hypoglycaemia. This may cause sweatiness, tremulousness and hunger. If the hypoglycaemia is severe, it can result in confusion, loss of consciousness and seizures. Treatment involves raising the blood sugar level. If the person is conscious, they should eat or drink sugary foods such as six jelly beans or a glass of apple juice to raise the sugar level immediately, followed by eating foods with carbohydrates, such as a piece of bread, to prevent the hypoglycaemia from recurring. They should also retest their blood sugar level after five minutes. If the person is unconscious, then help from another person is required, and treatment either with a medication called glucagon or an intravenous drip is given. Often this involves calling the ambulance.

Another important aspect of diabetes management is regular screening for complications. Good management of sugar levels can help decrease the risk of complications, and screening for complications is important to detect early disease so that late disease can be prevented. Kidney disease is screened for once a year with a spot urine test looking for protein in the urine and a blood test of renal function. Eye disease is screened for once a year with an examination of the retina (which is the lining of the back of the eye which captures light thus enabling sight) by an optometrist or eye specialist doctor (ophthalmologist). This may occur more frequently in people with evidence of disease.

Table 2
Common medications used in the management of diabetes in Australia

Medication	Examples	Route of administration	Conventionally used in Type 1 diabetes	Conventionally used in Type 2 diabetes
Insulin	Rapid-acting Short-acting Intermediate-acting Long-acting Mixed	Injection (subcutaneously)	Yes. Main treatment for type 1 diabetes	Yes
Biguanide	Metformin	Tablet form	Generally no. Sometimes used with insulin	Yes
Sulfonylurea	Gliclazide Glimepiride	Tablet form	No	Yes
GLP-1 agonist	Exenatide Liraglutide	Injection (subcutaneously)	No	Yes
DPP4 inhibitor	Alogliptin Linagliptin Sitagliptin Saxagliptin Vildagliptin	Tablet form	No	Yes
SGLT2 inhibitor	Empagliflozin Dapagliflozin	Tablet form	No	Yes
Alpha glucosidase inhibitor	Acarbose	Tablet form	No	Yes

Driving, pregnancy and diabetes

Two important issues arising from the management of diabetes are driving and pregnancy. A person's ability to drive can be affected by having diabetes. The glucose-lowering medications to treat diabetes may put the person at risk of having a low blood sugar or hypoglycaemic event while driving. Having a hypoglycaemic event that does not cause an altered state of consciousness may impair the person's ability to drive, and have a similar effect on a person as driving under the influence of alcohol. This risk is greatest if

patients are on medications that can cause hypoglycaemia — mainly insulin and sulphonylureas (see Table 2). To minimise the risk of this occurring, patients should check their blood sugar levels before they drive and ensure that they are above 5 mmol/L. Diabetes can also affect a person's vision through diabetic eye disease, and affect a person's ability to press on their brake pedal or clutch, or turn their steering wheel, through diabetic nerve damage. Consequently, patients with diabetes need to alert their local road/traffic/driving authority.

Pregnancy must be a planned event for women with diabetes, and sexually active women with diabetes should use contraception to prevent unplanned pregnancies. Pregnancy can worsen the management of diabetes, and diabetes in turn can result in pregnancy complications. When pregnancy is considered, a female with diabetes should seek medical advice from their general practitioner and/or specialist. The blood sugar control must be extremely good before and during the pregnancy, as a high sugar level during pregnancy can cause multiple complications for the developing baby. Additionally, certain medications used to treat diabetes, such as DPP4 inhibitors or even particular medications used to treat high blood pressure and high cholesterol levels, should not be taken in pregnancy as they can cause complications for the developing baby. They must be stopped or changed to safer medications.

Preventing diabetes

> The medical literature tells us that the most effective ways to reduce the risk of heart disease, cancer, stroke, diabetes, Alzheimer's, and many more problems are through healthy diet and exercise. Our bodies have evolved to move, yet we now use the energy in oil instead of muscles to do our work.
> — David Suzuki

While active research is underway exploring ways to prevent type 1 diabetes, for those at risk of type 2 diabetes, weight loss through eating a healthy diet (following the principles outlined earlier) and

increasing physical activity can decrease the risk. This in turn can prevent development of complications of diabetes such as kidney disease or heart disease. Prevention of type 2 diabetes, and therefore subsequent complications of diabetes, is important and needs to be considered by all members of the community.

Summary

Diabetes mellitus is a chronic condition characterised by high blood sugar levels and sweet urine. There are two main types of diabetes — type 1 diabetes, where the affected person requires insulin, and type 2 diabetes, which may be associated with being overweight and physically inactive. Diabetes can lead to other complications such as kidney disease, eye disease or heart disease. It is growing into a serious public health problem, due to the increasing number of people developing type 2 diabetes. Management of diabetes is a journey, with a partnership between the patient, the patient's family and the health professional, and involves the patient making diet and lifestyle changes and taking medications. It not only involves good control of sugar levels, but managing other conditions that can damage blood vessels, such as high blood pressure or high cholesterol levels. Good management of diabetes can delay and prevent the onset of diabetes complications such as kidney or heart disease. Given the increasing incidence of diabetes, it is vital that management also focuses on prevention of type 2 diabetes. More public education encouraging a healthy diet and increased physical activity is required to prevent people from beginning on the journey of diabetes in the first place. As the old idiom goes — prevention is better than cure.

Acknowledgements

The authors would like to acknowledge Mr M Lo, Mrs G Lo, and Mrs E Lilburn for providing feedback on the clarity of the chapter.

Endnotes

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