Type 2 diabetes in adults

Straight to the point of care

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The cornerstone of therapy for all patients with diabetes is a personalised self-management programme, usually developed with the patient by a diabetes education nurse or nutritionist.

Lifestyle changes plus metformin are initial antihyperglycaemic therapy for most patients. Glycaemic goals and treatment choices are individualised.

Selected glucose-lowering drugs reduce all-cause and cardiovascular mortality. Addition of a sodium-glucose co-transporter 2 (SGLT2) inhibitor or glucagon-like peptide-1 (GLP-1) agonist is recommended in patients with long-standing suboptimal glycaemic control plus established cardiovascular and/or renal disease.

Blood pressure control, lipid management, smoking cessation, and glycaemic management reduce the risk of macrovascular complications such as heart attack and stroke. Glycaemic control and blood pressure management reduce the risk of microvascular complications (neuropathy, nephropathy, retinopathy).
Definition

Type 2 diabetes mellitus is a progressive disorder defined by deficits in insulin secretion and action that lead to abnormal glucose metabolism and related metabolic derangements.[1] Although the aetiologies of type 1 and type 2 diabetes differ dramatically, both lead to hyperglycaemic states, and both share common macrovascular (coronary heart, cerebrovascular, and peripheral vascular disease) and microvascular (retinopathy, nephropathy, and neuropathy) complications. Type 2 diabetes is most often diagnosed following routine screening. It is preceded by a state of pre-diabetes, which is defined by a single fasting plasma glucose of 5.6-6.9 mmol/L (100-125 mg/dL) or a HbA1c of 39-46 mmol/mol (5.7% to 6.4%) in the absence of diabetes. Diabetes diagnosis is based on two confirmed values of: fasting plasma glucose >6.9 mmol/L (125 mg/dL); HbA1c of 48 mmol/mol (6.5%) or greater; or (less commonly) abnormal glucose tolerance test results, or a random plasma glucose of ≥11.1 mmol/L (≥200 mg/dL) plus symptoms of hyperglycaemia. A single blood sample is sufficient to establish a diabetes diagnosis if assays of both HbA1c and fasting plasma glucose meet criteria for diabetes diagnosis.[2]

Epidemiology

Diabetes prevalence is increasing worldwide, compounded by population growth and an ageing population.[3] In 1980, the global age-standardised diabetes prevalence was 4.3%. In 2017, the global age-standardised diabetes prevalence was estimated at 8.6%.[4] Survey data of diabetes in adults does not separate type 1 and type 2 diabetes, but most cases of diabetes (around 90%) are type 2.[3] However, while the overall burden of diabetes is increasing, trends in the incidence rate of diabetes plateaued and now appear to be decreasing. Data from the US National Health Interview Survey documented that the incidence of age-adjusted, diagnosed diabetes decreased from 2007 to 2017, from 7.8 to 6.0 per 1000 adults.[5]

Incidence and prevalence of type 2 diabetes have risen steadily since 1950, driven by increasing prevalence in obesity and being overweight.[6] In the US in 2017, type 2 diabetes had a prevalence of 8.5%.[7] In the UK, prevalence rates of type 2 diabetes increased from 3.21% in 2004 to 5.26% in 2014, and incidence rates remained stable.[8] Clinical onset is usually preceded by many years of insulin resistance and hyperinsulinaemia before elevated glucose levels are detectable.[1]

Patients with type 2 diabetes have a very high risk of concurrent hypertension (80% to 90%), lipid disorders (70% to 80%), and overweight or obesity (60% to 70%).[9] When diabetes is diagnosed at age 40 years, men lose an average of 5.8 years of life, and women lose an average of 6.8 years of life, highlighting the importance of primary prevention of diabetes.[10] However, onset of diabetes at older ages has much less effect on life expectancy if acceptable glucose, blood pressure, and lipid control can be achieved and maintained.

Aetiology

Type 2 diabetes often presents on a background genetic predisposition and is characterised by insulin resistance and relative insulin deficiency. Insulin resistance is aggravated by ageing, physical inactivity, and overweight (body mass index [BMI] 25-29.9 kg/m²) or obesity (BMI >30 kg/m²). Among obese patients, weight loss often reduces the degree of insulin resistance and may delay diabetes onset or ameliorate diabetes severity and thereby reduce risk of long-term complications. Insulin resistance affects primarily the liver, muscle, and adipocytes, and it is characterised by complex derangements in cellular receptors, intracellular glucose kinase function, and other intracellular metabolic processes.[6] The complexity and
variety of these intracellular derangements suggest that what is now classified as type 2 diabetes may be in fact a larger group of conditions that await future definition.

Pathophysiology

The precise mechanism by which the diabetic metabolic state leads to microvascular and macrovascular complications is only partly understood but probably involves both uncontrolled blood pressure (BP) and uncontrolled glucose, increasing the risk of microvascular complications such as retinopathy and nephropathy. Mechanisms may involve defects in aldose reductase and other metabolic pathways, damage to tissues from accumulation of glycated end products, and other mechanisms. With respect to macrovascular complications, high BP and glucose raise risk, but so do lipid abnormalities and tobacco use. One unifying theory postulates the existence of a metabolic syndrome that includes diabetes mellitus, hypertension, dyslipidaemias, and obesity, and predisposes to coronary heart disease, stroke, and peripheral artery disease.[6] However, this theory is not universally accepted as more clinically useful than assessing individual cardiovascular risk factors.[11]
**Primary prevention**

Lifestyle factors (obesity, physical inactivity, and stress) seem to be the main drivers of the current diabetes epidemic. With aggressive prevention of obesity in all age groups, type 2 diabetes is potentially preventable.[29] [30] Several clinical trials have shown that weight loss is associated with delayed or decreased onset of diabetes in high-risk adults.[14] [23] [24] [25] [31] [32] Progression to diabetes from pre-diabetic states can be reduced by 50% over 3 to 4 years through modest weight loss (7% of body weight) using diet and regular physical activity.[23] In addition, several pharmacological agents, including metformin, alpha-glucosidase inhibitors, orlistat, glucagon-like peptide 1 (GLP-1) receptor agonists, and thiazolidinediones, have been shown to reduce progression from pre-diabetes to diabetes.[2] [26] [33] [34] [35] Lifestyle change and/or metformin are preferred for most patients.[36] [37] [38] [39] More aggressive multi-agent pharmacological approaches remain controversial.[40] Screening for pre-diabetes and cardiovascular risk reduction appropriate to the needs of the individual are also very important.[27] [41] [42]

**Screening**

The US Preventive Services Task Force (USPSTF) now recommends screening for glucose status for adults aged 40 to 70 years who have body mass index (BMI) ≥25. Those with normal test results should be re-screened every 3 years. Those who have pre-diabetes should subsequently be screened annually for diabetes.[60]

The American Diabetes Association (ADA) has recommended routine screening of non-pregnant asymptomatic adults of any age with BMI ≥25 kg/m² (≥23 kg/m² for people from South Asia) plus one or more risk factors for diabetes. Those without risk factors should be screened starting at age 45 years. Risk factors for diabetes include family history of diabetes, overweight or obesity, sedentary lifestyle, high-risk ancestry, gestational diabetes, hypertension, dyslipidaemia (low HDL-cholesterol and/or elevated triglycerides), vascular disease, glucose intolerance, or polycystic ovary syndrome.[2]

Recommended screening tests include fasting plasma glucose (pre-diabetes if 5.6 to 6.9 mmol/L [100-125 mg/dL] once, in the absence of diabetes) and/or HbA1c (pre-diabetes if 39-46 mmol/mol [5.7% to 6.4%] once, in the absence of diabetes; diabetes if ≥48 mmol/mol [≥6.5%] twice). Oral 75 g glucose tolerance test is less commonly used in non-pregnant adults.[2]

**Secondary prevention**

Although the risk of macrovascular complications can be reduced by over 50% using effective multifactorial interventions,[200] a US national survey found more than half of outpatients over age 50 years with diabetes and hypertension did not receive an antiplatelet agent, statin therapy, or ACE inhibitor/angiotensin-II receptor antagonist.[201]

Other preventative measures include:[2]

- Annual influenza immunisations
- Vaccination against pneumococcal disease
- Hepatitis B vaccination for unvaccinated diabetic adults aged 19 to 59 years; considered for unvaccinated diabetic adults aged 60 years and older
- Regular dental care
- Tailored diabetes education.
Case history

Case history #1

An overweight 55-year-old woman presents for preventative care. She notes that her mother died of diabetes, but reports no polyuria, polydipsia, or weight loss. BP is 144/92 mmHg, fasting blood sugar 8.2 mmol/L (148 mg/dL), HbA1c 65 mmol/mol (8.1%), LDL-cholesterol 5.18 mmol/L (200 mg/dL), HDL-cholesterol 0.8 mmol/L (30 mg/dL), and triglycerides 6.53 mmol/L (252 mg/dL).

Other presentations

Patients with type 2 diabetes can also present with symptoms such as blurred vision; fatigue; erectile dysfunction; urinary tract or candidal infections; dry itchy skin; paresthesias; increased urination, thirst, and appetite; or unexplained weight loss.

Step-by-step diagnostic approach

Type 2 diabetes is most often diagnosed on routine screening. Strong risk factors, which also indicate the need for screening, include: older age; overweight/obesity; black, Hispanic, or Native American ancestry; family history of type 2 diabetes; history of gestational diabetes; presence of pre-diabetes; physical inactivity; polycystic ovary syndrome; hypertension; dyslipidaemia; or known cardiovascular disease.[2] Symptomatic patients may present with: fatigue; polyuria, polydipsia, polyphagia, or weight loss (usually when hyperglycaemia is more severe [e.g., >16.6 mmol/L, >300 mg/dL]); blurred vision; paraesthesias; unintentional weight loss; nocturia; skin infections (bacterial or candidal); urinary infections; or acanthosis nigricans.

Diagnosis

One of four tests can be used to establish a firm diagnosis of diabetes:[2]

- Fasting plasma glucose (FPG) >6.9 mmol/L (>125 mg/dL)
- Random plasma glucose ≥11.1 mmol/L (≥200 mg/dL) with diabetes symptoms such as polyuria, polydipsia, fatigue, or weight loss
- 2-hour post-load glucose ≥11.1 mmol/L (≥200 mg/dL) on a 75 g oral glucose tolerance test
- HbA1c ≥48 mmol/mol (≥6.5%).

All of these require confirmation with a second test, which may be the same test or a different test. This means a single blood sample is sufficient to establish a diabetes diagnosis if assays of both HbA1c and fasting plasma glucose meet criteria for diabetes diagnosis.[2] Some variability in HbA1c results is possible as a result of such factors as increased red blood cell turnover (e.g., sickle cell anaemia), factors related to ancestry,[43] or laboratory variation.

Some individuals cannot be clearly classified as having type 1 or type 2 diabetes at the time of diagnosis.[2] However, at initial diagnosis of diabetes, it is important to determine if immediate treatment with insulin is required. Type 1 diabetes can occur at any age but usually is diagnosed in younger (age <35 years), thinner patients, and has a more rapid onset and often more severe symptoms. Around one
third of patients with newly diagnosed type 1 diabetes present with diabetic ketoacidosis (DKA). However, DKA may also occur in type 2 diabetes, particularly if there is an underlying infection. Urine ketones should be checked if patients are symptomatic of hyperglycaemia (polyuria, polydipsia, weakness) and volume depletion (dry mucous membranes, poor skin turgor, tachycardia, hypotension, and, in severe cases, shock) at diagnosis or throughout course of disease.

C-peptide is produced in equal amounts to insulin and is the best measure of endogenous insulin secretion in patients with diabetes. There is no role for routine testing for C-peptide for diagnosis of diabetes, but measuring C-peptide may be useful in differentiating type 1 and type 2 diabetes. The best evidenced C-peptide test is the glucagon stimulation test (GST), but non-fasting ‘random’ blood C-peptide has been shown to correlate with fasting C-peptide and post-GST samples in subjects with well-defined type 1 or type 2 diabetes. Development of absolute insulin deficiency is a key feature of type 1 diabetes, which results in low (<0.2 nanomol/L) or undetectable levels of plasma C-peptide. A GST or non-fasting ‘random’ blood C-peptide level >1 nanomol/L suggests type 2 diabetes. C-peptide results must be interpreted in clinical context of disease duration, comorbidities, and family history.

**Evaluation of disease and risks of macrovascular/microvascular complications**

Blood pressure, smoking status, and fasting lipid levels should be assessed. Baseline urine albumin/creatinine ratio and serum creatinine with estimated glomerular filtration rate (eGFR) are also indicated, as signs of chronic kidney disease may be present at diagnosis. Clinical assessment of cardiac, carotid, and peripheral circulation, with ECG and vascular investigation (e.g., an ankle-brachial index) can be considered at diagnosis. Examination of the feet, including assessment of ankle reflexes, pulses, vibratory sensation, and monofilament touch sensation, and a dilated retinal examination, should be part of the evaluation. HbA1c, lipid levels, blood pressure, urine albumin excretion, renal function, and clinical assessment are monitored at periodic intervals.

**Risk factors**

**Strong**

older age
- Older patients are at increased risk. However, the incidence of type 2 diabetes in children and adolescents is increasing.

overweight/obesity
- Appears to be the precipitating factor leading to clinical expression of diabetes. The mean body mass index (BMI) at the time of diagnosis of diabetes in several studies is around 31 kg/m², and there is a graded increase in risk of diabetes with increasing BMI. Clinical trials have shown that weight loss is associated with delayed or decreased onset of diabetes in high-risk adults.

gestational diabetes
- About 50% of women who have gestational diabetes mellitus will go on to develop overt diabetes mellitus within 10 years of delivery.
pre-diabetes
• Major risk factor for onset of type 2 diabetes. Progression from pre-diabetes to overt type 2 diabetes occurs at the rate of about 2% to 4% per year.[1] [2]

family history of type 2 diabetes
• Although the specific genetic profile that confers risk has yet to be fully elucidated, epidemiological observations leave little doubt of a substantial genetic component.[6]

non-white ancestry
• Prevalence of diabetes varies by ethnic group. Differential prevalence rates have been observed for European Americans, Hispanic Americans, and African-Americans,[16] with people of African, Hispanic, or American-Indian ancestry at higher risk of diabetes compared with white people.[17] In the UK, type 2 diabetes is more common in people of African, African-Caribbean, and South Asian family origin.[18] South Asian and East Asian people are at increased risk of developing type 2 diabetes, probably due to an interplay of diet, lifestyle, and genetic factors.[19] [20] [21] [22]

physical inactivity
• While the impact on increased risk of diabetes is mediated in part through obesity/overweight, several interventions studies indicate that increased levels of physical activity delay or decrease onset of diabetes in high-risk adults.[23] [24] [25] [26]

polycystic ovary syndrome
• Elevated risk; should be periodically screened for diabetes.[2]

hypertension
• Often associated with type 2 diabetes. Periodic screening is recommended in people with essential hypertension due to increased prevalence of diabetes.[2]

dyslipidaemia
• Especially with low high-density lipoprotein (HDL) and/or high triglycerides: periodic diabetes screening is recommended due to the high prevalence of diabetes in patients with dyslipidaemia.[2]

cardiovascular disease
• Periodic diabetes screening is recommended due to the high prevalence of diabetes in patients with peripheral vascular and coronary artery disease.[2]
• American College of Cardiology/American Heart Association statements identify a number of additional risk factors for atherosclerotic cardiovascular disease, which include: C-reactive protein ≥2 mg/L; coronary artery calcium score ≥100 Agatston units or ≥75% for age, sex, and ethnicity; and ankle-brachial index <0.9.[27]

stress
• Stress provokes release of hormones that elevate glucose, and there is some evidence that life stress may predispose to onset of type 2 diabetes.[28]
**History & examination factors**

### Key diagnostic factors

#### presence of risk factors (common)
- Key risk factors include older age; overweight/obesity; black, Hispanic, or Native American ancestry; family history of type 2 diabetes; history of gestational diabetes; presence of pre-diabetes; physical inactivity; polycystic ovary syndrome; hypertension; dyslipidaemia; or known cardiovascular disease.
- One unifying theory postulates the existence of a metabolic syndrome that includes diabetes mellitus, hypertension, dyslipidaemias, and obesity, and predisposes to coronary heart disease, stroke, and peripheral artery disease.[49] However, this theory is not universally accepted as more clinically useful than assessing individual cardiovascular risk factors.[50]

#### asymptomatic (common)
- It is very common for type 2 diabetes to be asymptomatic and detected on screening. Symptoms, when present, may indicate more overt hyperglycaemia.

#### candidal infections (common)
- Most commonly vaginal, penile, or in skin folds.

#### skin infections (common)
- Cellulitis or abscesses.

#### urinary tract infections (common)
- Cystitis or pyelonephritis.

### Other diagnostic factors

#### fatigue (common)
- Increased fatigability may be an early warning sign of progressive cardiovascular disease; clinicians should have a low threshold for cardiac evaluation.

#### blurred vision (common)
- Due to elevated glucose.

#### polydipsia (uncommon)
- Usually in patients with fasting plasma glucose >16.6 mmol/L (>300 mg/dL), HbA1c >95 mmol/mol (>11%).

#### polyphagia (uncommon)
- Usually in patients with fasting plasma glucose >16.6 mmol/L (>300 mg/dL), HbA1c >95 mmol/mol (>11%).

#### polyuria (uncommon)
- Usually in patients with fasting plasma glucose >16.6 mmol/L (>300 mg/dL), HbA1c >95 mmol/mol (>11%).

#### paraesthesias (uncommon)
Type 2 diabetes in adults

Diagnosis

- May occur in the extremities as a result of neuropathy in those with prolonged undiagnosed diabetes.

**Nocturia (uncommon)**
- Due to glucose-induced diuresis.

**Unintentional weight loss (uncommon)**
- If marked hyperglycaemia is present.

**Acanthosis nigricans (uncommon)**
- A velvety, light brown-to-black marking, usually on the neck, under the arms, or in the groin. Can occur at any age. Most often associated with obesity.

[Fig-1]

Diagnostic tests

**1st test to order**

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>HbA1c</td>
<td>48 mmol/mol (6.5%) or greater&lt;br&gt;Confirm with a repeat HbA1c or another diagnostic test.[2] HbA1c is also used to monitor glycaemic control, usually every 3 months.</td>
</tr>
<tr>
<td>Fasting plasma glucose</td>
<td>&gt;6.9 mmol/L (&gt;125 mg/dL)&lt;br&gt;Order after a minimum 8-hour fast. Confirm an elevated result with an HbA1c (which can be done on the same sample), a second fasting plasma glucose, or another diabetes diagnostic test.[2]</td>
</tr>
<tr>
<td>Random plasma glucose</td>
<td>≥11.1 mmol/L (≥200 mg/dL)&lt;br&gt;Non-fasting test. Convenient, but less accurate than either fasting plasma glucose, HbA1c, or 75 g oral glucose tolerance test.[2] Used for rapid assessment of glucose status if symptoms such as polyuria, polydipsia, or weight loss are present.</td>
</tr>
<tr>
<td>2-hour post-load glucose after 75 g oral glucose</td>
<td>≥11.1 mmol/L (≥200 mg/dL)&lt;br&gt;More costly and inconvenient than fasting plasma glucose or HbA1c. Diabetes should be confirmed on a separate occasion with another diagnostic test.[2]</td>
</tr>
</tbody>
</table>
## Other tests to consider

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>fasting lipid profile</strong></td>
<td>• Dyslipidaemia is common in type 2 diabetes.</td>
</tr>
<tr>
<td></td>
<td><strong>may show high LDL, low HDL, and/or high triglycerides</strong></td>
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<tr>
<td><strong>urine ketones</strong></td>
<td>• Urine ketones should be checked if patients are symptomatic</td>
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<tr>
<td></td>
<td>of hyperglycaemia (polyuria, polydipsia, weakness) and volume</td>
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<tr>
<td></td>
<td>depletion (dry mucous membranes, poor skin turgor, tachycardia,</td>
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<tr>
<td></td>
<td>hypotension, and, in severe cases, shock) at diagnosis or throughout</td>
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<tr>
<td></td>
<td>course of disease. Ketoacidosis is a common presentation of type 1</td>
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<tr>
<td></td>
<td>diabetes, but can also occur in type 2 diabetes. [44] [45] [46]</td>
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<tr>
<td></td>
<td><strong>positive in instances of ketoacidosis</strong></td>
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<tr>
<td><strong>random C-peptide</strong></td>
<td>• Not done routinely for diagnosis of diabetes, but may be useful</td>
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<tr>
<td></td>
<td>in differentiating type 1 and type 2 diabetes. [47]</td>
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<tr>
<td></td>
<td>Absolute insulin deficiency is a key feature of type 1 diabetes, which</td>
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<td></td>
<td>results in low (&lt;0.2 nanomol/L) or undetectable levels of plasma C-peptide. [2] [47]</td>
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<tr>
<td></td>
<td>C-peptide results must be interpreted in clinical context of disease</td>
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<tr>
<td></td>
<td>duration, comorbidities, and family history. [48]</td>
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<tr>
<td></td>
<td><strong>&gt;1 nanomol/L</strong></td>
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<tr>
<td><strong>urinary albumin excretion</strong></td>
<td>• Indicates nephropathy and suggests possible other microvascular</td>
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<tr>
<td></td>
<td>damage. Monitored yearly.</td>
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<td></td>
<td>• May be assessed with albumin-to-creatinine ratio in a random urine</td>
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<tr>
<td></td>
<td>sample. [2]</td>
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<tr>
<td></td>
<td><strong>may be increased</strong></td>
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<tr>
<td><strong>serum creatinine and estimated GFR</strong></td>
<td>• GFR is calculated according to the Chronic Kidney Disease</td>
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<tr>
<td></td>
<td>Epidemiology Collaboration (CKD-EPI) or Modification of Diet in</td>
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<td></td>
<td>Renal Disease (MDRD) formulas. The CKD-EPI formula is now recommended</td>
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<td>by the Kidney Disease Outcomes Quality Initiative (KDOQI) because it</td>
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<td>removes bias at higher GFR levels, allowing for reporting across a full</td>
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<tr>
<td></td>
<td>range.</td>
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<td></td>
<td><strong>may show renal insufficiency</strong></td>
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<tr>
<td><strong>ECG</strong></td>
<td>• Baseline assessment. A normal ECG does not rule out coronary</td>
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<tr>
<td></td>
<td>artery disease. Patients with an abnormal resting ECG may require</td>
</tr>
<tr>
<td></td>
<td>further cardiac investigation. [2]</td>
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<tr>
<td></td>
<td><strong>may indicate prior ischaemia</strong></td>
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<tr>
<td><strong>ankle-brachial index (ABI)</strong></td>
<td>• A non-invasive tool to detect peripheral arterial disease (PAD),</td>
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<td></td>
<td>which has a high prevalence in patients with diabetes. The American</td>
</tr>
<tr>
<td></td>
<td>Diabetes Association recommends that ABI should be performed in</td>
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<tr>
<td></td>
<td>patients with symptoms of PAD. [2] Can be used to screen for PAD.</td>
</tr>
<tr>
<td></td>
<td><strong>≤0.9 is abnormal</strong></td>
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<tr>
<td><strong>dilated retinal examination</strong></td>
<td>• Patients should be referred to an ophthalmologist at the time of</td>
</tr>
<tr>
<td></td>
<td>diagnosis of type 2 diabetes. [2]</td>
</tr>
<tr>
<td></td>
<td><strong>may show retinopathy</strong></td>
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</tbody>
</table>
# Differential diagnosis

<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
</tr>
</thead>
</table>
| **Pre-diabetes** | • Patients with pre-diabetes often have no specific differentiating signs or symptoms. | • Fasting plasma glucose level is 5.6 to 6.9 mmol/L (100-125 mg/dL) in pre-diabetes.  
• 2-hour post-load glucose after 75 g of oral glucose is 7.8 to 11.0 mmol/L (140-199 mg/dL) in pre-diabetes.  
• HbA1c of 38-47 mmol/mol (5.7% to 6.4%) indicates pre-diabetes and high risk of future diabetes.[2] |
| **Diabetes mellitus, type 1** | • Onset often at age <35 years, but can occur in older individuals.  
• Many patients are not obese.  
• More commonly presents with symptoms (polyuria, polydipsia, weight loss, generalised weakness, blurred vision) and ketosis, rather than being detected by screening.[44] | • Urine ketones are often present in type 1 diabetes, but may be positive in type 2 diabetes if there is severe volume depletion.  
• Low (<0.2 nanomol/L) or absent C-peptide level.  
• One or more auto-antibodies (antiglutamic acid decarboxylase [GAD] antibodies, islet cell antibodies [ICA], insulin auto-antibodies, auto-antibodies to the tyrosine phosphates IA-2 and IA-2beta) are present in 85% of patients with type 1 at the time of diagnosis, but may disappear within a few years.[51] Type 1 diabetes is defined by the presence of one or more of these autoimmune markers, but testing is usually not required for diagnosis.  
• Glucose screening criteria cannot be used to differentiate type 1 and type 2 diabetes, as they are identical. |
<p>| <strong>Latent autoimmune diabetes in adults (LADA)</strong> | • Typical age of onset of diabetes is over 30 years old. Patients are usually non-obese and respond initially to lifestyle modifications and oral agents. Production of insulin gradually decreases (between 6 months and 5 years). | • Positive for at least 1 of the 4 antibodies commonly found in type 1 diabetic patients (ICAs and auto-antibodies to GAD65, IA-2, and insulin).[53] |</p>
<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
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</thead>
</table>
| **Monogenic diabetes**     | • Maturity-onset diabetes of the young (MODY) is the most common form of monogenic diabetes and affects 1% to 2% of people with diabetes.[54]  
  • MODY is caused by mutation of a single gene (i.e., monogenic). As of 2011, at least 11 forms of MODY are known.[55]  
  • It has autosomal dominant inheritance and should be suspected in cases of diabetes in non-obese, young patients (adolescence or young adult) with family history of diabetes in two or more successive generations.[55]  
  • Patients are often misclassified as type 1 or type 2 diabetes. Insulin treatment is often not needed. | • Genetic testing in patients with high index of suspicion (genes encoding glucokinase and transcription factors are identified).[56] |
| **Ketosis-prone diabetes** | • Presents with unprovoked ketosis or ketoacidosis.[57]  
  • Considered an ‘idiopathic diabetes’, as patients have no evidence of autoimmunity. Often misclassified as type 1 diabetes, as individuals have episodic ketoacidosis and exhibit varying degrees of insulin deficiency between episodes. However, a type 2 diabetes phenotype is common (obesity, insulin resistance, metabolic syndrome).[58]  
  • Patients are usually from a minority ethnic group, and have a positive family history of diabetes.[58]  
  • On discontinuation of insulin therapy, the period of near-normoglycaemic remission | • Absent islet cell auto-antibodies.  
  • C-peptide often low or undetectable during diabetic ketoacidosis; recovery may be used as reliable predictor of insulin discontinuation.[58] |
<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>may last for a few months</td>
<td></td>
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<tr>
<td>to several years. However,</td>
<td></td>
<td>Gestational diabetes is generally detected by screening during pregnancy. Based on the current evidence, the US Preventive Services Task Force recommends screening for gestational diabetes in asymptomatic pregnant women after 24 weeks of gestation. One-step or 2-step screening strategies may be used. When overt hyperglycaemia occurs during pregnancy, it may be difficult to distinguish between undetected pre-existing type 2 diabetes and gestational diabetes.</td>
</tr>
<tr>
<td>almost half will be insulin</td>
<td></td>
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<tr>
<td>dependent 10 years after</td>
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</tr>
<tr>
<td>diagnosis.[57]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes, gestational</td>
<td>Only occurs during pregnancy.</td>
<td></td>
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**Diagnostic criteria**

**American Diabetes Association[2]**

One of four tests can be used to establish a firm diagnosis of diabetes:

- Fasting plasma glucose (FPG) >6.9 mmol/L (>125 mg/dL) (most commonly used)
- Random plasma glucose ≥11.1 mmol/L (≥200 mg/dL) with diabetes symptoms such as polyuria, polydipsia, fatigue, or weight loss
- 2-hour post-load glucose ≥11.1 mmol/L (≥200 mg/dL) on a 75 g oral glucose tolerance test
- HbA1c ≥48 mmol/mol (≥6.5%).

All of these require confirmation with a second test, which may be the same test or a different test. One option is to test both HbA1c and FPG on a single blood sample.
Step-by-step treatment approach

For updates on diagnosis and management of coexisting conditions during the pandemic, see our topic 'Management of coexisting conditions in the context of COVID-19'.

The cornerstone of therapy for all patients with type 2 diabetes is a personalised management programme that includes pharmacotherapy and ongoing self-management education by a diabetes education nurse or nutritionist.[61] [62] [63] Diabetes self-management education promotes diabetes self-care and supports beneficial lifestyle changes on an ongoing basis.[2] This requires general nutrition and health lifestyle knowledge and an individualised nutrition and exercise plan based on an initial assessment and treatment goals. Interventions that enhance self-management can significantly reduce diabetes distress.[64]

About 80% of adults with type 2 diabetes have concurrent dyslipidaemias or hypertension, 70% are overweight or obese, and around 15% are current smokers.[9] On average, adults with type 2 diabetes are up to twice as likely to die of stroke or myocardial infarction (MI) compared with those without diabetes, and they are more than 40 times more likely to die of macrovascular than microvascular complications of diabetes.[65] [66] [67] However, data indicate that adults with type 2 diabetes who optimally manage glucose, blood pressure, lipids, smoking, and weight have a risk of major cardiovascular events that is not significantly above the risk of age and sex-matched non-diabetes peers.[68] [69]

Therefore, care of adults with type 2 diabetes must include management of all major cardiovascular risk factors to individualised targets. In addition to glucose control, this includes smoking cessation, blood pressure control, lipid control, antplatelet use for patients with known coronary heart disease, and ACE inhibitors or angiotensin-II receptor antagonists for patients with chronic kidney disease or proteinuria.[2] [41] [70] In addition, use of antihyperglycaemic agents that reduce cardiovascular or overall mortality or cardiovascular events may be especially beneficial in those who have type 2 diabetes and established cardiovascular disease.[2] [41] [71]

**Diet**

Nutrition therapy involves limiting caloric intake to achieve recommended weight, while offering a diversified and appealing menu of food choices.[72] Nutrition advice needs to be tailored to the needs of each individual patient, preferably by a nutritionist.[2] [29] The optimal mix of carbohydrate, fats, and protein depends upon renal status, achieved lipid levels, body mass index (BMI), and level of glycaemic control, among other factors. Low-carbohydrate diets appear to be beneficial for glycaemic control in type 2 diabetes management.[73] Saturated fat should be limited to <10% of calories.[29] Reducing sugary beverage consumption (including milk, fizzy drinks, energy drinks, and fruit juice) is of benefit to many patients.[29] Weight loss management programmes with a healthy eating and physical activity plan resulting in an energy deficit have the potential for type 2 diabetes remission.[29] [74] [75] The Diabetes Remission Clinical Trial (DiRECT) of supported weight loss management for people diagnosed with type 2 diabetes within the previous 6 years, and a BMI of 27kg/m² to 45 kg/m², found that almost half of participants achieved remission to a non-diabetic state and off antidiabetic drugs at 12 months.[74] At 2 years, more than a third of people with type 2 diabetes had sustained remission.[76]

**Exercise and sleep**

- To improve glycaemic control, assist with weight maintenance, and reduce cardiovascular risk, moderate physical activity is recommended as tolerated. The ACC/AHA has recommended that, in general, adults should engage in 3 to 4 sessions of aerobic physical activity per week, with each
Type 2 diabetes in adults

Treatment

session lasting on average 40 minutes, and involving moderate- to vigorous-intensity physical activity.[77] Walking frequently in proper footwear is a recommended activity.[2]

- In addition, gentle strength training that targets all major muscle groups may be beneficial if done for 20 minutes 2 to 3 times per week on non-consecutive days. Patients with severe or symptomatic heart disease may require evaluation before increasing levels of physical activity.[2]
- People should be encouraged to limit the amount of time they spend being sedentary by avoiding extended amounts of time spent sitting.
- Older adults may benefit from flexibility training and balance training 2-3 times/week (e.g., with yoga or tai chi).
- An assessment of sleep duration and quality should be considered. Obesity, diabetes, hypertension, atrial fibrillation, and male sex are risk factors for sleep apnoea, and inadequate sleep may affect glycaemic control.[2]

Cardiovascular risk management

Blood pressure

Blood pressure guidelines differ regarding recommended targets for those with diabetes.

- The 2017 American College of Cardiology/American Heart Association guideline for management of high blood pressure (BP) in adults recommends BP <130/80 mmHg for people with diabetes, and classifies BP using the following categories:[78]
  - normal (<120/80 mmHg)
  - elevated (120-129/<80 mmHg)
  - stage 1 (130-139/80-89 mmHg)
  - stage 2 hypertension (≥140/90 mmHg).
- The American Diabetes Association Standards of Medical Care in Diabetes recommends goal BP <140/90 mmHg for people with diabetes, with consideration of a goal BP <130/80 mmHg for those with established hypertension and diabetes and who have established cardiovascular disease or 10-year cardiovascular risk greater than 15%.[2] [79]
- Regardless of specific blood pressure goal, initial treatment with an ACE inhibitor, an angiotensin-II receptor antagonist, a calcium-channel blocker, or a thiazide (or thiazide-like) diuretic is preferred. Black people may benefit most from a thiazide diuretic or a calcium-channel blocker.[79] ACE inhibitors may reduce mortality and cardiovascular events more than angiotensin-II receptor antagonists.[70] Combination drug therapy (with ACE inhibitor/angiotensin-II receptor antagonist, calcium-channel blocker, thiazide diuretic) is often required to reach blood pressure goals. Combined use of an ACE inhibitor and an angiotensin-II receptor antagonist is not recommended due to increased risk of adverse events.[80] However, most people with chronic kidney disease (CKD) should receive an ACE inhibitor or an angiotensin-II receptor antagonist as part of their antihypertensive regimen.[79] CKD is defined as (a) age <70 years with glomerular filtration rate (GFR) <60 mL/minute/1.73 m², or (b) people of any age with albuminuria >30 mg albumin/g of creatinine at any level of GFR.
- Beta-blockers are not contraindicated in people with diabetes but are less-preferred antihypertensive agents[79] and may mask symptoms of hypoglycaemia. ACE inhibitors may increase risk for hypoglycaemia in conjunction with insulin or an insulin secretagogue (e.g., sulfonylurea or meglitinide).[81]
Type 2 diabetes in adults

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- If blood pressure remains uncontrolled on first-line therapies, discontinue or minimise interfering substances such as non-steroidal anti-inflammatory drugs (NSAIDs), evaluate for secondary causes of hypertension (including obstructive sleep apnoea), and consider the addition of a mineralocorticoid receptor agonist,[82] and/or refer to a hypertension specialist.
- Blood pressure goals and guidelines are evolving as more studies are carried out. The Systolic Blood Pressure Intervention Trial (SPRINT) was terminated early, as it found that a lower systolic target of 120 mmHg reduced cardiovascular complications and deaths in people aged over 50 years with high blood pressure and at least one additional risk factor for heart disease.[83] However, people with diabetes were excluded from this trial.
- There is an increasing emphasis to incorporate the use of home blood pressure monitoring into the diagnosis and management of hypertension in adults, including those with diabetes.[84]

Lipids

- The American College of Cardiology/American Heart Association (ACC/AHA) guidelines recommend high-intensity statin therapy if tolerated in adults aged over 21 years if the patient has clinical atherosclerotic cardiovascular disease (ASCVD) or low-density lipoprotein (LDL)-cholesterol ≥4.9 mmol/L (≥190 mg/dL).[85] In those aged 40 to 75 years with diabetes but no ASCVD, moderate-intensity statin therapy should be considered. In those with diabetes and 10-year ACC/AHA cardiovascular risk greater than 20%, consider adding ezetimibe to maximally-tolerated statin therapy to reduce LDL by 50% or more.[85] In diabetes patients aged over 75 years, it is reasonable to consider and discuss with the patient advantages and disadvantages of initiation or continuation of statin therapy.[85] In those aged 20 to 39 years with diabetes, it may be reasonable to initiate statin therapy in the presence of albuminuria, estimated GFR <60 mL/minute/1.73 m², retinopathy, or neuropathy.[85] Statins are contraindicated in pregnancy.
- The American Diabetes Association (ADA) recommends that management of lipid abnormalities is driven by risk status rather than LDL cholesterol level.[2] Risk factors for cardiovascular disease include LDL-cholesterol >2.6 mmol/L (>100 mg/dL), high blood pressure, smoking, and overweight and obesity. Lifestyle therapy is recommended for all people. For people with diabetes and overt cardiovascular disease, high-intensity statin therapy is added to lifestyle therapy, regardless of baseline lipid values. High-intensity statin therapy is also considered for those aged over 40 years without overt cardiovascular disease, but with one or more cardiovascular disease (CVD) risk factors. For people with diabetes aged over 40 years without additional CVD risk factors, moderate-intensity statin therapy is still considered. For some patients with diabetes and established coronary heart disease who have persistently elevated LDL despite maximally-tolerated statin therapy, addition of ezetimibe or a proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitor (e.g., alirocumab, evolocumab) may confer clinical benefit.[2] [86] [87] [88]

Smoking cessation

- Patients who smoke should be provided with smoking cessation resources, and be provided with smoking cessation assistance such as medications and counselling as appropriate. Varenicline combined with nicotine replacement therapy may be more effective than varenicline alone.[89] The ADA does not support e-cigarettes as an alternative to smoking or to facilitate smoking cessation.[2]

Antiplatelet therapy

- Adults with cardiovascular disease should receive aspirin for secondary prevention. Clopidogrel is an alternative for patients with aspirin allergy or intolerance. Dual antiplatelet therapy is reasonable...
for up to 12 months after an acute coronary syndrome. The main adverse effect is an increased risk of gastrointestinal bleeding.[2] [90]

- The ADA recommends that aspirin therapy be considered for primary prevention in adults with type 2 diabetes aged 50 to 70 years who are at increased cardiovascular risk (family history of premature cardiovascular disease, hypertension, dyslipidaemias, smoking, chronic kidney disease/albuminuria), unless they are at high risk of serious bleeding.[2]
- US Preventive Services Task Force (USPSTF) recommendations for primary prevention of heart attack or stroke in those aged 50 to 70 years are similar.[91]

Antihyperglycaemic pharmacotherapy: initial considerations

HbA1c goals should be individualised.[92] [93] For many patients, the goal HbA1c <7% is appropriate. However, HbA1c 7.0% to 7.9% may be more appropriate in some patients, such as those with advanced age, limited life expectancy, known cardiovascular disease, high risk of severe hypoglycaemia, or difficulty achieving lower HbA1c goals despite use of multiple antihyperglycaemic medications and insulin.[2] Individualised HbA1c goals improve quality of life compared with uniform tight control.[93]

If HbA1c is above goal, pharmacotherapy is recommended to reduce risk of both microvascular (nephropathy, retinopathy, neuropathy) and macrovascular (myocardial infarction, stroke, peripheral vascular disease) complications.[94] [95] Data suggest that preventing major cardiovascular events and renal complications of diabetes may be affected not only by HbA1c levels but also by strategic selection of specific antihyperglycaemic medications. Some specific antihyperglycaemic medications significantly reduce all-cause or cardiovascular mortality, or major cardiovascular events or renal complications in some patient subgroups, and for such patients, these agents may be preferred.[71] Among the antihyperglycaemic medications that reduce cardiovascular mortality in some patient subgroups are metformin,[96] empagliflozin, canagliflozin, and liraglutide.[71]

In older studies such as ACCORD, ADVANCE, and the Veterans Affairs Diabetes Trial (VADT), use of multiple drugs to achieve near-normal HbA1c was either not beneficial or increased mortality in type 2 diabetes patients with CVD or high CVD risk.[97] [98] [99] [100] [101] However, sodium-glucose co-transporter 2 (SGLT2) inhibitors were not available and glucagon-like peptide-1 (GLP-1) agonists were infrequently used in those studies.

Patients with type 2 diabetes using multiple daily insulin injections or an insulin pump should self-monitor blood glucose three or more times daily. For patients using less frequent insulin injections or non-insulin therapies, self-monitoring may be useful to guide therapy.[2]

Choice of agents should be individualised, taking into account patient values and preferences, the likelihood that an agent reduces all-cause or cardiovascular mortality, renal effects, adverse effects, costs, and other factors.

Metformin is the recommended first-choice therapy at diagnosis in the absence of contraindications because of its safety profile and likely cardiovascular benefit.[94] [96] Metformin may be safely used in patients with reduced estimated glomerular filtration rates (eGFRs), but it is contraindicated if eGFR <30 mL/minute/1.73 m².[2] [102] Metformin should not be initiated if the eGFR is <45 mL/minute/1.73 m², and, for patients taking metformin whose eGFR falls to within the 30-45 mL/minute/1.73 m² range, continued use can be considered with close monitoring of renal function and a dose reduction.[102] [103] People who are unable to take metformin due to contraindications or intolerance can either use an alternative non-insulin agent or start insulin therapy. Basal-bolus insulin is used as initial treatment
Type 2 diabetes in adults

TREATMENT

(without metformin) for those with type 2 diabetes and very high initial glucose levels (>16.6 mmol/L [>300 mg/dL]).

In patients with diabetes without diagnosed cardiovascular disease, if metformin is used as initial treatment and fails to achieve goals after 3 months, a second agent may be added based on individualised assessment of necessary clinical benefit, safety considerations, costs, and patient preference:[102]

- Sodium-glucose co-transporter 2 (SGLT2) inhibitor: canagliflozin, dapagliflozin, empagliflozin, or ertugliflozin
- Glucagon-like peptide-1 (GLP-1) agonist: lixisenatide, lixisenatide, semaglutide, or dulaglutide
- Dipeptidyl peptidase-4 (DPP-4) inhibitor: sitagliptin, saxagliptin, linagliptin, or alogliptin
- Sulfonylurea: gliclazide, glipizide, pioglitazone, or glimepiride; meglitinides (e.g., repaglinide, nateglinide) are an alternative
- Alpha-glucosidase inhibitor: acarbose or miglitol
- Thiazolidinedione: pioglitazone
- Insulin.

In patients with diabetes and with diagnosed cardiovascular disease, if metformin is used as initial treatment and fails to achieve goals after 3 months, a second agent may be added. Addition of a SGLT2 inhibitor or GLP-1 agonist is recommended in patients with long-standing sub-optimal glycaemic control plus established cardiovascular and/or renal disease.[2] [102] [104]

- SGLT2 inhibitor: canagliflozin or empagliflozin may be preferred.
- GLP-1 agonist: liraglutide may be preferred.

There are many appropriate 3-agent combinations of glucose-lowering therapy that do not involve insulin. Choice of second and third antihyperglycaemic medications may differ depending on cardiovascular comorbidities.[102] When 2- or 3-drug non-insulin regimens fail, basal insulin can be added. Bolus insulin can be subsequently added if needed to achieve or maintain adequate glucose control. To reduce the risk of hypoglycaemia, a sulfonylurea is usually tapered if insulin is started.

Clinical properties of specific oral antihyperglycaemic agents

Agents are often selected based on a discussion with the patient of the pros and cons of the agents. Agents that reduce all-cause or cardiovascular mortality may be preferred.[41]

- Metformin can promote weight loss and may reduce cardiovascular events and mortality.[94] [96]
- SGLT2 inhibitors (canagliflozin, dapagliflozin, empagliflozin, ertugliflozin) inhibit renal glucose reabsorption. The resulting increase in glycosuria improves glycemic control, promotes weight loss, and has a diuretic effect that reduces blood pressure.[105] There is evidence that use of SGLT2 inhibitors prevents major kidney outcomes (dialysis, transplantation, or death due to kidney disease) in people with type 2 diabetes.[106] Empagliflozin and canagliflozin have been shown to reduce cardiovascular risk in people with CVD and type 2 diabetes, and may have renal benefits.[71] [107] [108] [109] [110] Empagliflozin and canagliflozin have been shown to significantly reduce cardiovascular or all-cause mortality in those with diabetes and established cardiovascular disease.[111] [112] [113] In one trial, treatment with dapaglifozin in patients with type 2 diabetes who had, or were at risk for, atherosclerotic cardiovascular disease did not result in a lower rate of major adverse cardiovascular events, but did report a lower rate of hospitalisation for
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heart failure. Trials on the CVD benefits of ertugliflozin are ongoing. [115] [116] [117] Adverse effects for different agents have included a higher rate of genital infections, diabetic ketoacidosis, acute kidney injury, fracture, and/or amputation. [111] [118] [119] Notably, the US Food and Drug Administration (FDA) has confirmed an increased risk of leg and foot amputations with canagliflozin. [120] The European Medicines Agency (EMA) also warns of the potential increased risk of toe amputation with SGLT2 inhibitors. [121] For canagliflozin, the prescribing information will also list lower-limb amputation as an uncommon side effect. [122] The FDA and the UK Medicines and Healthcare products Regulatory Agency (MHRA) warn of cases of necrotising fasciitis of the perineum (also known as Fournier’s gangrene) observed in post-marketing surveillance of SGLT2 inhibitors. [123] [124] Thus, SGLT2 inhibitors should be avoided in patients with conditions that increase the risk for limb amputations, and in patients prone to urinary tract or genital infections.

- GLP-1 agonists (liraglutide, exenatide, lixisenatide, semaglutide, dulaglutide) are suitable for obese patients without gastroparesis who desire weight loss, are willing to take injections, and can tolerate the common adverse effect of initial nausea. [125] In one review, GLP-1 agonist use led to loss of 1.4 kg versus placebo, and loss of 4.8 kg versus insulin. [126] As a class of drugs, GLP-1 agonist treatment has beneficial effects on cardiovascular, mortality, and kidney outcomes in patients with type 2 diabetes. [127] Liraglutide significantly reduced cardiovascular mortality and all-cause mortality in those with diabetes and cardiovascular disease or high CVD risk in one randomised trial. [128] Dulaglutide and semaglutide have both been shown to reduce major cardiovascular events, but not all-cause or cardiovascular mortality. [129] [130] [131] Exenatide and lixisenatide have both been shown not to reduce major cardiovascular events. [132] The MHRA warns of cases of diabetic ketoacidosis in patients with type 2 diabetes on a combination of a GLP-1 receptor agonist and insulin who had doses of concomitant insulin rapidly reduced or discontinued. [133]

- DPP-4 inhibitors (sitagliptin, saxagliptin, linagliptin, alogliptin) are well tolerated, weight-neutral, but confer no mortality benefit.

- Sulfonylureas (glipizide, glimepiride, glyburide) are the subject of long clinical experience and may reduce microvascular complications, but confer no mortality benefit and may cause weight gain and hypoglycaemia. [102] Along with metformin and human insulin, these are among the more affordable antihyperglycaemic medications. [134]

- Alpha-glucosidase inhibitors (acarbose, miglitol) can be added to metformin in people with large postprandial glucose excursions, but increased flatus and gastrointestinal (GI) side effects are common. There is no strong evidence of a benefit on all-cause or cardiovascular mortality.

- Thiazolidinediones (pioglitazone, rosiglitazone) lower blood sugar effectively but more than double the risk of congestive heart failure, often causing weight gain and oedema. [102] They may cause anaemia and increase fracture rates in both women and men. In addition, rosiglitazone raises LDL-cholesterol and mixed evidence suggests that rosiglitazone may increase the risk of cardiovascular events. [135] Rosiglitazone has been removed from the European market due to persistent safety concerns. [136] However, in 2013, the US Food and Drug Administration (FDA) lifted previous restrictions applied to rosiglitazone in the US, based on newer data. [137] As a result of an updated review, the FDA has concluded that use of pioglitazone may be linked to an increased risk of bladder cancer. [138]

- Bromocriptine and colesevelam are oral agents approved for glucose-lowering in some countries. They have limited impact on blood glucose in many patients. Bromocriptine may cause GI side effects. Colesevelam, originally approved as a bile-acid sequestrant, requires multiple doses per day, and may bind other medications. Neither of these agents is widely used for glucose control at present.
Insulin therapy

Insulin therapy is required for severe hyperglycaemia and is an option when metformin monotherapy or multi-drug regimens are inadequate. Usually this is initiated with long-acting basal insulin at bedtime. Some patients’ blood sugars can be well controlled with a combination of non-insulin therapy and one injection of basal insulin. However, some patients will need to use both a long-acting basal insulin (e.g., detemir, glargine, or degludec) injection once daily and rapid-acting insulin (e.g., lispro, aspart, or glulisine) injected before each meal. Intermediate (NPH) and short-acting (regular) insulins are other choices for basal-bolus regimens. For patients with type 2 diabetes, human insulins are as effective as analogue insulins for glucose control, serious hypoglycaemia risk, and mortality and cardiovascular events.[139] Human insulins are less expensive than analogue insulins. Pre-mixed insulin is available. Regimens should be individualised. Insulin delivery devices that can be programmed to administer set doses of insulin are now available and may be used by patients to help them achieve glycaemic control. As insulin doses increase, any sulfonylurea should be tapered, but metformin may be continued.

Insulin treatment should be considered at the time of diagnosis if glucose level is ≥16.6 mmol/L (≥300 mg/dL) or if HbA1c is ≥86 mmol/mol (≥10%). For these patients with marked hyperglycaemia, metformin can be used adjunctively, in the absence of nausea, vomiting, or volume depletion.

Exogenous insulin is a very effective way to lower serum glucose and lower HbA1c, but its use must be guided in most patients by regular self-monitored blood glucose testing. Hypoglycaemia (glucose ≤3.9 mmol/L [≤70 mg/dL]) is the most serious potential complication of insulin therapy. Another significant side effect is weight gain. Less common side effects may include hunger, nausea, diaphoresis, injection site irritation, or anaphylaxis.

Correction doses of insulin

When basal-bolus insulin is used by motivated and knowledgeable patients, the dose of rapid-acting insulin that is administered before each meal can be based on anticipated carbohydrate content of the upcoming meal and sometimes adjusted for anticipated physical activity. Correctional doses of rapid-acting insulin can also be applied based on pre-meal blood sugar readings (correctional algorithms). One acceptable method of determining a correction algorithm is to divide 1800 by the total daily dose of insulin to yield the expected blood sugar reduction per unit of insulin. For example, for a patient taking 60 units of insulin per day, the expected blood sugar lowering of 1 additional unit of insulin would be 1800/60=30 mg/dL (1.7 mmol/L).

Bariatric surgery for treatment of diabetes in patients with obesity

Randomised clinical trials have shown a benefit from bariatric surgery (also referred to as metabolic surgery) with regard to diabetes remission, glycaemic control, need for glucose-lowering medications, quality of life, and reduction in cardiovascular risk factor markers over the short term (e.g., 1-3 years) in people with type 2 diabetes as compared with medical therapy alone.[140] [141] [142] [143] [144] as well as for possible prevention of type 2 diabetes.[145] Cohort studies suggest that both Roux en Y bypass and sleeve gastrectomy procedures lead to diabetes remission that lasts a mean of about 5 years in more than half of patients, and significantly reduce mortality, stroke, myocardial infarction, and microvascular complications in those with type 2 diabetes.[146] [147] [148] Compared with sleeve gastrectomy, Roux en Y leads to somewhat greater weight loss and other benefits, but is a more technically challenging operation with higher re-operation and readmission rates. The benefits and risks of bariatric surgery also vary substantially across type 2 diabetes patient subgroups. In observational studies, average benefits
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Treatment

appeared to be highest in those who are younger (age 40-50 years), those with more recent onset of type 2 diabetes, and those not on insulin therapy.[149]

Bariatric surgery may be considered for adults with BMI ≥40 kg/m² (≥37.5 kg/m² for people of Asian-family origin) with any level of glycaemic control/any complexity of glucose-lowering regimen.[2] Surgery may also be considered for adults with BMI 35.0 to 39.9 kg/m² (32.5 to 37.4 kg/m² for people of Asian-family origin) with hyperglycaemia inadequately controlled despite lifestyle and optimal medical management, and may be considered for those with BMI 30.0 to 34.9 kg/m² (27.5 to 32.4 kg/m² for people of Asian-family origin) with hyperglycaemia inadequately controlled despite optimal use of oral or injectable medications (including insulin).[2] Bariatric surgery is best done in a high-volume, specialised centre.[2]

Treatment of diabetes in pregnancy

Good glucose control with HbA1c as close to normal as is safely possible (ideally HbA1c <6.5% [48 mmol/mol]) before conception and during pregnancy optimises maternal and fetal health outcomes.[2] [150] ADA guidelines recommend the following blood glucose targets in pregnant women with pre-existing type 2 diabetes (the same as for gestational diabetes): <5.3 mmol/L (<95 mg/dL) fasting, and either ≤7.8 mmol/L (≤140 mg/dL) 1-hour postprandially or ≤6.7 mmol/L (≤120 mg/dL) 2-hour postprandially, with HbA1c goal individualised between <42-48 mmol/mol (<6% to <6.5%) or up to <53 mmol/mol (<7%) as necessary to prevent hypoglycaemia.[2] Target blood glucose values in pregnant women according to guidelines from the UK National Institute for Health and Care Excellence are, if safely achievable, a preprandial glucose 5.3 mmol/L (95 mg/dL), at 1-hour postprandial glucose below 7.8 mmol/L (140 mg/dL), and at 2-hour postprandial glucose below 6.4 mmol/L (115 mg/dL).[151] [Evidence C]

In clinical practice, insulin is usually used when nutrition therapy fails to achieve these goals. NPH insulin may be combined with human short-acting or analogue rapid-acting insulin. Long-acting analogue insulins (glargine, detemir, or degludec) are not approved in pregnancy. ACE inhibitors, angiotensin-II receptor antagonists, and beta-blockers are not recommended in pregnancy and should be avoided. Statins are contraindicated in pregnancy. Retinal exam in those with diabetes prior to pregnancy should be performed prior to, during, and after pregnancy. Women with diabetes who anticipate pregnancy or are pregnant benefit from care supervision by a specialised centre whenever possible.

Care delivery models

Diabetes care has, on average, dramatically improved in the past 20 years, with a 50% reduction in mortality rates, cardiovascular mortality rates, and cardiovascular event rates in adults with diabetes.[13] Many factors have contributed to diabetes care improvement and better clinical outcomes for patients.[152] The principal model used to frame these strategies is the Chronic Care Model.[153] The model includes 6 core elements: delivery system design, self-management support, decision support, clinical information systems, community resources and policies, and health systems.

Evidence is generally supportive of the following care improvement strategies.

- A multidisciplinary team approach to patient care, including the involvement of trained diabetes self-management educators, pharmacists, and case managers[154] [155]
- Advanced and integrated electronic medical record clinical decision support beyond simple reminder systems and alerts[156] [157]
- Simulated case-based learning interventions for clinicians.[158] [159] [160]

Other re-designs to the care delivery system such as alternative reimbursement methods, public policy changes to support healthier lifestyles, the patient-centred medical home, and mobile health (mHealth)
Type 2 diabetes in adults

Technology may provide additional opportunities to improve care and are currently being evaluated.[161][162] Diabetes management decisions should be timely, rely on evidence-based guidelines, and be made collaboratively with the patient.

Treatment details overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer.

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### Acute

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### Without marked hyperglycaemia non-pregnant asymptomatic: serum glucose <16.6 mmol/L (<300 mg/dL) or HbA1c <86 mmol/mol (<10%) |

| HbA1c above goal at diagnosis | 1st | metformin + cardiovascular risk reduction/lifestyle measures |
| HbA1c above goal on metformin | 1st | sodium-glucose co-transporter 2 (SGLT2) inhibitor added to continued metformin + continued cardiovascular risk reduction/lifestyle measures |
| 1st | glucagon-like peptide 1 (GLP-1) agonist added to continued metformin + continued cardiovascular risk reduction/lifestyle measures |
| 1st | dipeptidyl peptidase-4 (DPP-4) inhibitor added to continued metformin + continued cardiovascular risk reduction/lifestyle measures |
| 1st | sulfonylurea or meglitinide added to continued metformin + continued cardiovascular risk reduction/lifestyle measures |
| 1st | basal insulin added to continued metformin + continued cardiovascular risk reduction/lifestyle measures |
| 2nd | alpha-glucosidase inhibitor added to continued metformin + continued cardiovascular risk reduction/lifestyle measures |
| 2nd | thiazolidinedione added to continued metformin + continued cardiovascular risk reduction/lifestyle measures |

| HbA1c above goal on metformin + either basal insulin or second non-insulin agent | 1st | Individualised augmented regimen + continued cardiovascular risk reduction/lifestyle measures |
### Acute

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<td><strong>switch to basal-bolus insulin + continued cardiovascular risk reduction/lifestyle measures</strong></td>
<td><strong>adjunct continued metformin</strong></td>
<td><strong>bariatric surgery</strong></td>
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**pregnant**

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<td><strong>diet + basal-bolus insulin</strong></td>
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Treatment options

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer.
Initial treatment at initial diagnosis

1st lifestyle changes

- Although pharmacotherapy is usually indicated in patients with HbA1c >53 mmol/mol (>7%), lifestyle changes are key to diabetes management.

- The cornerstone of therapy for all patients with diabetes is a personalised self-management programme, usually developed by a diabetes education nurse or nutritionist.[2] [61] [62] General nutrition and healthy lifestyle information and an individualised nutrition and exercise plan based on an initial assessment and treatment goals can significantly reduce diabetes distress.[64]

- Nutrition therapy involves limiting caloric intake to achieve recommended weight, while offering a diversified and appealing menu of food choices. Nutrition advice needs to be tailored to the needs of each individual patient.[2] [29] [72] The optimal mix of carbohydrate, fats, and protein depends upon renal status, achieved lipid levels, body mass index, and level of glycaemic control, among other factors. Reducing sugary beverage consumption (including milk, fizzy drinks, energy drinks, and fruit juice) is of benefit to many patients.

- Moderate physical activity is recommended as tolerated to improve glycaemic control, assist with weight maintenance, and reduce cardiovascular risk. It is recommended that, in general, adults should engage in 3 to 4 sessions of aerobic physical activity per week, with each session lasting on average 40 minutes and involving moderate- to vigorous-intensity physical activity.[77]

- Weight loss management programmes with a healthy eating and physical activity plan resulting in an energy deficit have the potential for type 2 diabetes remission.[29] [74] [75]

- Alcohol use (more than 2 drinks daily for men or 1 for women) increases risk of hypoglycaemia, as well as other untoward events.

- Smoking cessation is imperative. Patients who smoke should be provided with smoking cessation resources and assistance.

- Achieving recommended goals for weight management, nutrition, and physical activity benefits many aspects of health, including
### Initial

<table>
<thead>
<tr>
<th>Glucose, blood pressure, lipid control, and depression prevention or control, and decreases risk of major cardiovascular events and onset or progression of microvascular complications.</th>
</tr>
</thead>
</table>

**plus**

**glycaemic management**

Treatment recommended for ALL patients in selected patient group

- All patients should receive stratified glycaemic management upon diagnosis.
- HbA1c goals should be individualised,[92] and if HbA1c is above goal, pharmacotherapy recommended.
- Choice of agents should be individualised, taking into account patient values and preferences, likelihood that an agent reduces all-cause or cardiovascular mortality, adverse effect profiles, costs, and other factors. For most patients, metformin will be initial therapy, but insulin may be required for marked hyperglycaemia.
- Consult a specialist for guidance on treating pregnant women.

**plus**

**blood pressure management**

Treatment recommended for ALL patients in selected patient group

**Primary options**

- **hydrochlorothiazide:** 12.5 to 25 mg/day orally once daily initially, increase gradually according to response, maximum 50 mg/day as a single dose or in 2 divided doses
  - **or**
  - **chlortalidone:** 12.5 mg orally once daily initially, increase gradually according to response, maximum 50 mg/day
  - **or**
  - **indapamide:** 1.25 mg orally once daily initially, increase gradually according to response, maximum 5 mg/day

--AND/OR--

- **lisinopril:** 10 mg orally once daily initially, increase gradually according to response, maximum 40 mg/day
  - **or**
  - **enalapril:** 5 mg orally once daily initially, increase gradually according to response, maximum 40 mg/day as a single dose or in 2 divided doses
  - **or**
<table>
<thead>
<tr>
<th>Initial</th>
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</table>
| » **captopril**: 25 mg orally twice daily initially, increase gradually according to response, maximum 200 mg/day  
  -or-  
  » **candesartan**: 4 mg orally once daily initially, increase gradually according to response, maximum 32 mg/day  
  -or-  
  » **irbesartan**: 75 mg orally once daily initially, increase gradually according to response, maximum 300 mg/day  
  -or-  
  » **losartan**: 50 mg orally once daily initially, increase gradually according to response, maximum 100 mg/day as a single dose or in 2 divided doses  
  -or-  
  » **valsartan**: 40-80 mg orally once daily initially, increase gradually according to response, maximum 320 mg/day  
  --AND/OR--  
  » **amlodipine**: 2.5 mg orally once daily initially, increase gradually according to response, maximum 10 mg/day  
  -or-  
  » **felodipine**: 2.5 mg orally once daily initially, increase gradually according to response, maximum 10 mg/day  
  -or-  
  » **nifedipine**: 30-60 mg orally (extended-release) once daily initially, increase gradually according to response, maximum 90 mg/day  
  -or-  
  » **diltiazem**: 120-180 mg orally (extended-release) once daily initially, increase gradually according to response, maximum 480 mg/day |

» Adults with type 2 diabetes are twice as likely to die of stroke or myocardial infarction (MI) compared with those without diabetes, and they are more than 40 times more likely to die of macrovascular than microvascular complications of diabetes. [65] [66] [67] A primary goal of diabetes care is evidence-based management of cardiovascular risk factors to individualised goals.

» Blood pressure guidelines differ somewhat regarding recommended blood pressure targets for those with diabetes; however, American Diabetes Association (ADA) guidelines recommend a treatment goal of <140/90 mmHg or <130/80 mmHg for those with diabetes and cardiovascular disease or cardiovascular risk >15%. [2] [78] [79]
**Initial**

- Combination therapy is often required to reach blood pressure goals. Antihypertensive therapy may be initiated with a thiazide (or thiazide-like) diuretic, a calcium-channel blocker, an ACE inhibitor, or an angiotensin-II receptor antagonist. Antihypertensive drugs for black people may be initiated with a thiazide diuretic or a calcium-channel blocker.[79] ACE inhibitors may reduce mortality and cardiovascular events more than angiotensin-II receptor antagonists.[70]
- Combining an ACE inhibitor and an angiotensin-II receptor antagonist is not recommended due to increased risk of adverse events.[80]
- However, all people with chronic kidney disease (CKD) should receive an ACE inhibitor or an angiotensin-II receptor antagonist as part of their regimen.[79] CKD is defined as (a) age <70 years with glomerular filtration rate (GFR) <60 mL/minute/1.73 m², or (b) people of any age with albuminuria >30 mg albumin/g of creatinine at any level of GFR.
- If blood pressure remains uncontrolled on first-line therapies, discontinue or minimise interfering substances such as non-steroidal anti-inflammatory drugs (NSAIDs), evaluate for secondary causes of hypertension (including obstructive sleep apnoea), and consider the addition of a mineralocorticoid receptor agonist,[82] and/or refer to a hypertension specialist.
- Beta-blockers are not contraindicated in people with diabetes but are less-preferred antihypertensive agents[79] and may mask symptoms of hypoglycaemia.
- ACE inhibitors may increase risk for hypoglycaemia in conjunction with insulin or insulin secretagogue (sulfonylurea or meglitinide).[81]
- Consult a specialist for guidance on treating pregnant women. ACE inhibitors, angiotensin-II receptor antagonists, and beta-blockers are not recommended in pregnancy and should be avoided if possible.

**plus**  **lipid management**

Treatment recommended for ALL patients in selected patient group

**Primary options**

- **atorvastatin**: moderate intensity: 10-20 mg orally once daily; high intensity: 40-80 mg orally once daily
### Treatment

<table>
<thead>
<tr>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
</tr>
<tr>
<td>› rosuvastatin: moderate intensity: 5-10 mg orally once daily; high intensity: 20-40 mg orally once daily</td>
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<tr>
<td>OR</td>
</tr>
<tr>
<td>› simvastatin: moderate intensity: 20-40 mg orally once daily; increased risk of myopathy with 80 mg/day dose</td>
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<tr>
<td>OR</td>
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<tr>
<td>› pravastatin: moderate intensity: 40-80 mg orally once daily</td>
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<td>OR</td>
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<tr>
<td>› lovastatin: moderate intensity: 40-80 mg orally (immediate-release) once daily</td>
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<td>OR</td>
</tr>
<tr>
<td>› fluvastatin: moderate intensity: 40 mg orally (immediate-release) twice daily, or 80 mg orally (extended-release) once daily</td>
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<tr>
<td>OR</td>
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<tr>
<td>› pitavastatin: moderate intensity: 1-4 mg orally once daily</td>
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### Secondary options

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<th>Secondary options</th>
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<tr>
<td>OR</td>
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<tr>
<td>› atorvastatin: moderate intensity: 10-20 mg orally once daily; high intensity: 40-80 mg orally once daily</td>
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<tr>
<td>-or-</td>
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<tr>
<td>› rosuvastatin: moderate intensity: 5-10 mg orally once daily; high intensity: 20-40 mg orally once daily</td>
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<tr>
<td>› pravastatin: moderate intensity: 40-80 mg orally once daily</td>
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<tr>
<td>› lovastatin: moderate intensity: 40-80 mg orally (immediate-release) once daily</td>
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<tr>
<td>-or-</td>
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<tr>
<td>› pitavastatin: moderate intensity: 1-4 mg orally once daily</td>
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</tbody>
</table>
### Initial

- **fluvastatin**: moderate intensity: 40 mg orally (immediate-release) twice daily, or 80 mg orally (extended-release) once daily
  - **or**
  - **pitavastatin**: moderate intensity: 1-4 mg orally once daily

---

**AND**

- **ezetimibe**: 10 mg orally once daily

### Tertiary options

- **atorvastatin**: moderate intensity: 10-20 mg orally once daily; high intensity: 40-80 mg orally once daily
  - **or**
  - **rosuvastatin**: moderate intensity: 5-10 mg orally once daily; high intensity: 20-40 mg orally once daily
    - **or**
    - **simvastatin**: moderate intensity: 20-40 mg orally once daily; increased risk of myopathy with 80 mg/day dose
      - **or**
      - **pravastatin**: moderate intensity: 40-80 mg orally once daily
        - **or**
        - **lovastatin**: moderate intensity: 40-80 mg orally (immediate-release) once daily
          - **or**
          - **fluvastatin**: moderate intensity: 40 mg orally (immediate-release) twice daily, or 80 mg orally (extended-release) once daily
            - **or**
            - **pitavastatin**: moderate intensity: 1-4 mg orally once daily

---

**AND**

- **ezetimibe**: 10 mg orally once daily

---

**AND**

- **evolocumab**: 140 mg subcutaneously every 2 weeks; or 420 mg subcutaneously once monthly
  - **or**
  - **alirocumab**: 75-150 mg subcutaneously every 2 weeks; or 300 mg subcutaneously once monthly

---

> Adults with type 2 diabetes are twice as likely to die of stroke or myocardial infarction compared with those without diabetes, and they are more than 40 times more likely to die of macrovascular than microvascular complications of diabetes.[65] [66] [67] A primary goal of care is treatment of cardiovascular risk factors to individualised targets.[68]
Initial

- High-intensity statin therapy is recommended as tolerated in diabetes patients with atherosclerotic cardiovascular disease (ASCVD), 10-year cardiovascular risk >20%, or low-density lipoprotein (LDL)-cholesterol ≥4.9 mmol/L (≥190 mg/dL). Otherwise, in those aged 40 to 75 years, moderate-intensity statin therapy should be considered.[85] The guidelines recommend an individualised approach for people aged >75 years. A moderate-intensity statin has been defined by the American College of Cardiology/American Heart Association as one that generally lowers LDL-cholesterol level by 30% to 50%, while a high-intensity statin has been defined as one that lowers LDL-cholesterol level by ≥50%.[85]

- Combination therapy using statins and other lipid-lowering agents may be considered, especially in patients with very high CVD risk.[163] [164] The risks of complications such as impaired liver or renal function, myositis, or rhabdomyolysis may increase when using statins in combination with other agents.[2] Statin therapy may have some beneficial (e.g., anti-inflammatory) effects independent of lipid lowering.

- Ezetimibe or a proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitor (e.g., alirocumab, evolocumab) added to statin therapy may confer cardiovascular benefits to patients with diabetes and coronary heart disease who have LDL >1.8 mmol/L (>70 mg/dL) despite maximally-tolerated statin therapy.[2] [86] [88]

- Consult a specialist for guidance on treating pregnant women. Statins are contraindicated in pregnancy. There is a lack of data on the use of ezetimibe and PCSK9 inhibitors in pregnancy.

adjunct antiplatelet therapy

Treatment recommended for SOME patients in selected patient group

Primary options

- **aspirin**: 75-162 mg orally once daily

Secondary options

- **clopidogrel**: 75 mg orally once daily

OR

- **aspirin**: 75-162 mg orally once daily
  - **and**
  - **clopidogrel**: 75 mg orally once daily
Initial

» Adults with cardiovascular disease should receive aspirin for secondary prevention.

» Aspirin therapy may be considered for primary prevention in adults with type 2 diabetes aged 50 to 70 years who are at increased cardiovascular risk and do not have a contraindication to aspirin therapy.[2]

» Clopidogrel is an alternative for patients with aspirin allergy or intolerance.

» Dual antiplatelet therapy is often recommended for up to 1 year after an acute coronary syndrome. The main adverse effect is an increased risk of gastrointestinal bleeding.[2][90]

» The US Food and Drug Administration released a statement in 2014 citing inadequate evidence to support widespread use of aspirin for primary prevention of cardiovascular events.[165]

» Consult a specialist for guidance on treating pregnant women.
Type 2 diabetes in adults

**Treatment**

### Acute

marked hyperglycaemia non-pregnant: serum glucose ≥16.6 mmol/L (≥300 mg/dL) or HbA1c ≥86 mmol/mol (≥10%) or symptomatic

<table>
<thead>
<tr>
<th>1st</th>
<th>basal-bolus insulin + cardiovascular risk reduction/lifestyle measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Primary options</strong></td>
</tr>
<tr>
<td></td>
<td>» insulin isophane human (NPH): injected subcutaneously twice daily</td>
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<tr>
<td></td>
<td>-and-</td>
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<tr>
<td></td>
<td>» insulin neutral: injected subcutaneously two to three times daily</td>
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<td></td>
<td>OR</td>
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<tr>
<td></td>
<td>» insulin glargine: injected subcutaneously once daily</td>
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<td></td>
<td>» insulin detemir: injected subcutaneously twice daily</td>
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<td>-or-</td>
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<tr>
<td></td>
<td>» insulin degludec: injected subcutaneously once daily</td>
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<td>--AND--</td>
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<tr>
<td></td>
<td>» insulin lispro: injected subcutaneously pre-meals</td>
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<td>-or-</td>
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<tr>
<td></td>
<td>» insulin aspart: injected subcutaneously pre-meals</td>
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<tr>
<td></td>
<td>-or-</td>
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<tr>
<td></td>
<td>» insulin glulisine: injected subcutaneously pre-meals</td>
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<td></td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>» insulin isophane human/insulin neutral:</td>
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<tr>
<td></td>
<td>(50/50, 70/30) injected subcutaneously twice daily</td>
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<td></td>
<td>» insulin aspart protamine/insulin aspart:</td>
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<tr>
<td></td>
<td>(70/30) injected subcutaneously twice daily</td>
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<td></td>
<td>OR</td>
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<tr>
<td></td>
<td>» insulin lispro protamine/insulin lispro:</td>
</tr>
<tr>
<td></td>
<td>(50/50, 75/25) injected subcutaneously twice daily</td>
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<tr>
<td></td>
<td>OR</td>
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</tbody>
</table>
Acute

- **insulin degludec/insulin aspart (70/30)** injected subcutaneously once or twice daily with any main meal; administer a rapid- or short-acting insulin at other meals if needed

- Immediate insulin therapy should be considered for marked hyperglycaemia.

- Multi-dose insulin therapy can be started with long-acting insulin at 0.1 to 0.2 units/kg/day in the morning or bedtime. Adjustments can be made by 2-4 units every 3 days until fasting blood sugar levels are within target range. If pre-meal sugars remain over target, rapid-acting insulin can be added at meals (approximately 4 units) and titrated by 2 units every 3 days until within the desired range. It is common to start rapid-acting insulin with the meal with the largest blood sugar excursion and add injections for other meals as needed. The need for prandial insulin becomes more likely as the total insulin doses exceed 0.5 units/kg.[102]

- Insulin dose varies, with some patients with very poor control needing more aggressive management; refer to consultant as needed for guidance on dosage.

- Choice of insulin regimen should be individualised. For patients with type 2 diabetes, human insulins are as effective as analogue insulins for glucose control, serious hypoglycaemia risk, and mortality and cardiovascular events.[139] Human insulins are much less expensive than analogue insulins. Pre-mixed insulin may start with a total of about 0.3 units/kg/day dose of insulin, with two-thirds dose in the morning and one third in the evening, and titrated up until goals are achieved or hypoglycaemia prevents further titration. Insulin delivery devices that can be programmed to administer set doses of insulin are now available and may be used by patients to help them achieve glycaemic control.

- General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]

- Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should be instituted.

adjunct **metformin**

Treatment recommended for SOME patients in selected patient group
Type 2 diabetes in adults

Treatment

Acute

<table>
<thead>
<tr>
<th>Primary options</th>
</tr>
</thead>
<tbody>
<tr>
<td>» metformin: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily</td>
</tr>
<tr>
<td>» Metformin may be given adjunctively, in the absence of nausea/vomiting or volume depletion.</td>
</tr>
<tr>
<td>» Metformin reduces hyperglycaemia by decreasing hepatic gluconeogenesis and glycogenolysis. At maximal effective doses, metformin may reduce HbA1c by 10-20 mmol/mol (1% to 2%). It confers a cardiovascular benefit, is rarely associated with weight gain, is inexpensive, and has a beneficial effect on low-density lipoprotein cholesterol.</td>
</tr>
<tr>
<td>» The most common side effects are diarrhoea, gas, and nausea, which can be attenuated by initiating slowly 500 mg orally once a day with a meal, increasing as needed by 500 mg/day every 1 to 2 weeks until full dose of 1000 mg twice a day is reached.</td>
</tr>
<tr>
<td>» Metformin is contraindicated if estimated glomerular filtration rate (eGFR) is &lt;30 mL/minute/1.73 m². It should not be initiated if the eGFR is &lt;45 mL/minute/1.73 m², and for patients taking metformin whose eGFR falls to within the 30-45 mL/minute/1.73 m² range, continued use can be considered with close monitoring of renal function and a dose reduction.[102] [103]</td>
</tr>
<tr>
<td>» Metformin should be stopped before surgery or contrast dye studies with radiographic dye injection until adequate post-event renal function is documented.</td>
</tr>
<tr>
<td>» Periodic testing for vitamin B12 deficiency and B12 supplementation may be needed.[2]</td>
</tr>
</tbody>
</table>

without marked hyperglycaemia
non-pregnant asymptomatic: serum glucose <16.6 mmol/L (<300 mg/dL) or HbA1c <86 mmol/mol (<10%)

<table>
<thead>
<tr>
<th>HbA1c above goal at diagnosis</th>
<th>1st</th>
<th>metformin + cardiovascular risk reduction/lifestyle measures</th>
</tr>
</thead>
</table>

Primary options

» metformin: 500 mg orally (immediate-release) once daily initially, increase by 500
## Acute

<table>
<thead>
<tr>
<th>mg/day increments every week, maximum 1000 mg twice daily</th>
</tr>
</thead>
</table>

» If HbA1c is above individualised goal, pharmacotherapy is recommended to reduce risk of microvascular (nephropathy, retinopathy, neuropathy) and macrovascular (myocardial infarction, stroke, peripheral vascular disease) complications.⁹⁴ ⁹⁵

» The American Diabetes Association (ADA) recommends that metformin be started concurrently with non-pharmacological therapy when diabetes is diagnosed, because of the difficulty in achieving and maintaining lifestyle change.² People unable to take metformin should initiate individualised therapy with an alternative agent.

» Metformin may reduce cardiovascular mortality in type 2 diabetes.⁹⁴ ⁹⁶

» Metformin reduces hyperglycaemia by decreasing hepatic gluconeogenesis and glycogenolysis. At maximal effective doses, metformin may reduce HbA1c by 10-20 mmol/mol (1% to 2%). It rarely causes hypoglycaemia when used as monotherapy, rarely is associated with weight gain, is inexpensive, and has a beneficial effect on low-density lipoprotein cholesterol.

» The most common side effects are diarrhoea, gas, and nausea, which can be attenuated by initiating slowly 500 mg orally once a day with a meal, increasing as needed by 500 mg/day every 1 to 2 weeks until full dose of 1000 mg orally twice per day is reached.

» Periodic testing for vitamin B12 deficiency and B12 supplementation may be needed.²

» Metformin is contraindicated if estimated glomerular filtration rate (eGFR) is <30 mL/minute/1.73 m². It should not be initiated if the eGFR is <45 mL/minute/1.73 m², and for patients taking metformin whose eGFR falls to within the 30-45 mL/minute/1.73 m² range, continued use can be considered with close monitoring of renal function and a dose reduction.¹⁰² ¹⁰³

» Metformin should be stopped before surgery or contrast dye studies with radiographic dye injection until adequate post-event renal function is documented.
<table>
<thead>
<tr>
<th>Acute</th>
<th>1st</th>
</tr>
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<tbody>
<tr>
<td><strong>HbA1c above goal on metformin</strong></td>
<td><strong>sodium-glucose co-transporter 2 (SGLT2) inhibitor added to continued metformin + continued cardiovascular risk reduction/ lifestyle measures</strong></td>
</tr>
</tbody>
</table>

- Those unable to take metformin due to contraindication or intolerance can either use an alternative non-insulin agent or insulin therapy.
- General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]
- Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should be instituted.

### Primary options

- **metformin**: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily
  - **AND**
  - **empagliflozin**: 10 mg orally once daily, increase according to response, maximum 25 mg/day
    - **or**
    - **canagliflozin**: 100 mg orally once daily initially, increase according to response, maximum 300 mg/day
    - **or**
    - **dapagliflozin**: 5 mg orally once daily initially, increase according to response, maximum 10 mg/day
    - **or**
    - **ertugliflozin**: 5 mg orally once daily initially, increase according to response, maximum 15 mg/day

- Choice of agents should be individualised. The cardiovascular benefits and safety of some agents are much more strongly established than those of other agents, and such data should be strongly considered when selecting treatments.

- The SGLT2 inhibitors canagliflozin and empagliflozin have been shown to reduce cardiovascular risk in people with cardiovascular disease (CVD) and type 2 diabetes, and have renal benefits.[106] [107] [108] [109] [112]

One study of patients with type 2 diabetes and established CVD treated with empagliflozin for a median of 2.6 years resulted in lower rates of cardiovascular mortality, all-cause mortality, and hospitalisation for congestive heart failure,
### Acute

<table>
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<tr>
<th>compared with placebo.[111] Canagliflozin also reduces cardiovascular mortality,[113] but may have more adverse effects than empagliflozin. In one trial, treatment with dapagliflozin did not result in a lower rate of major adverse cardiovascular events, but did result in a lower rate of hospitalisation for heart failure.[114] Trials on the CVD benefits of ertugliflozin are ongoing.[116] [117]</th>
</tr>
</thead>
</table>

- The US Food and Drug Administration (FDA) has issued a warning that the SGLT2 inhibitor class of drugs (canagliflozin, dapagliflozin, empagliflozin, ertugliflozin) may lead to ketoacidosis. Patients should seek immediate medical attention for signs of ketoacidosis (difficulty breathing, nausea, vomiting, abdominal pain, confusion, and unusual fatigue or sleepiness).[166] The FDA has confirmed an increased risk of leg and foot amputations with canagliflozin.[120] The European Medicines Agency (EMA) also warns of the potential increased risk of toe amputation with approved SGLT2 inhibitors.[121] For canagliflozin, the prescribing information will also list lower-limb amputation as an uncommon side effect.[122] The FDA and the UK Medicines and Healthcare products Regulatory Agency (MHRA) warn of cases of necrotising fasciitis of the perineum (also known as Fournier's gangrene) observed in post-marketing surveillance of SGLT2 inhibitors.[123] [124]

- General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]

- Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.

#### 1st glucagon-like peptide 1 (GLP-1) agonist added to continued metformin + continued cardiovascular risk reduction/lifestyle measures

#### Primary options

- **metformin**: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily

- **liraglutide**: 0.6 mg subcutaneously once daily initially, increase by 0.6 mg/day
Type 2 diabetes in adults

TREATMENT

Acute

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Acute increments at weekly intervals according to response, maximum 1.8 mg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>— or —</td>
<td><strong>dulaglutide</strong>: 0.75 mg subcutaneously once weekly initially, may increase to 1.5 mg once weekly if response is inadequate</td>
</tr>
<tr>
<td>— or —</td>
<td><strong>semaglutide</strong>: 0.25 mg subcutaneously once weekly for 4 weeks initially, then increase to 0.5 mg once weekly for at least 4 weeks, then may increase to 1 mg once weekly if response is inadequate; 3 mg orally once daily for 30 days initially, then increase to 7 mg once daily for at least 30 days, then may increase to 14 mg once daily if response is inadequate</td>
</tr>
<tr>
<td>Important note: the subcutaneous formulation is given once weekly, while the oral formulation is given once daily</td>
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<tr>
<td>— or —</td>
<td><strong>exenatide</strong>: 5 micrograms subcutaneously twice daily initially, increase to 10 micrograms twice daily in one month; 2 mg subcutaneously (extended-release) once weekly</td>
</tr>
<tr>
<td>— or —</td>
<td><strong>lixisenatide</strong>: 10 micrograms subcutaneously once daily for 14 days, then increase to 20 micrograms once daily thereafter</td>
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</tbody>
</table>

As a class of drugs, GLP-1 agonist treatment has beneficial effects on cardiovascular, mortality, and kidney outcomes in patients with type 2 diabetes.[127] Choice of agents should be individualised. The cardiovascular benefits and safety of some agents are much more strongly established than those of other agents, and such data should be strongly considered when selecting treatments.

Liraglutide has been shown to reduce major cardiovascular events, cardiovascular mortality, and all-cause mortality in diabetes patients with coronary heart disease.[128] Dulaglutide and semaglutide have both been shown to reduce major cardiovascular events, but not all-cause or cardiovascular mortality.[129] [130] Exenatide and lixisenatide have both been shown not to reduce major cardiovascular events.[132] Semaglutide is the only GLP-1 agonist that is available in both oral and injectable formulations; the other GLP-1 agonists are only available in injectable formulations.

GLP-1 agonists stimulate glucose-dependent release of insulin, suppress glucagon levels, and may slow gastric emptying and increase
Type 2 diabetes in adults

**Acute**

satiety. GLP-1 agonists may be associated with modest initial weight loss on the order of 2 to 7 kg in some patients. GLP-1 agents may lower HbA1c up to 9 mmol/mol (0.9%) and may lower postprandial glucose.

» Response to the drug is quite variable and some patients will lose ground on glycaemic control due to reduction in doses of other glycaemic medicine when used as part of multi-drug regimens. Patients should be cautioned about this as well as potential risk of hypoglycaemia, and advised to check blood sugars frequently when initiating therapy. Patients should report any new problems with high or low readings.

» The Medicines and Healthcare products Regulatory Agency (MHRA) warns of cases of diabetic ketoacidosis in patients with type 2 diabetes on a combination of a GLP-1 receptor agonist and insulin who had doses of concomitant insulin rapidly reduced or discontinued.[133]

» General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]

» Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.

1st **dipeptidyl peptidase-4 (DPP-4) inhibitor added to continued metformin + continued cardiovascular risk reduction/lifestyle measures**

**Primary options**

» **metformin**: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily

--AND--

» **sitagliptin**: 100 mg orally once daily

- **linagliptin**: 5 mg orally once daily

- **alogliptin**: 25 mg orally once daily

- **saxagliptin**: 2.5 to 5 mg orally once daily

» Choice of agents should be individualised. The safety of some agents is more strongly established than the safety of other agents, and
### Acute

such data should be strongly considered when selecting treatments.

» DPP-4 inhibitors do not confer cardiovascular benefit, and do not lower glucose as much as metformin, sulfonylureas, or thiazolidinediones.

» Advantages include few identified side effects, less hypoglycaemia than sulfonylureas, less risk of weight gain or congestive heart failure than thiazolidinediones, and easy dosing. DPP-4 inhibitors do not appear to confer major risk of hypoglycaemia when studied as monotherapy.

» Studies of DPP-4 inhibitors showed that saxagliptin did not alter the rate of ischaemic events over about 2 years, although hospital admissions for heart failure increased.[167] In people with a recent acute coronary syndrome, alogliptin was not associated with increased risk of major adverse cardiovascular events over 40 months.[168]

» General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29][62]

» Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.

#### 1st sulfonylurea or meglitinide added to continued metformin + continued cardiovascular risk reduction/lifestyle measures

**Primary options**

» **metformin**: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily

--AND--

» **glimepiride**: 1-2 mg orally once daily initially, increase by 1-2 mg/day increments every 1-2 weeks, maximum 4 mg twice daily

-or-

» **glipizide**: 2.5 to 5 mg orally (immediate-release) once daily initially, increase by 2.5 to 5 mg/day increments every 1-2 weeks, maximum 10 mg twice daily; 5 mg orally (extended-release) once daily initially, increase to 10 mg once daily in 1-2 weeks if necessary

-or-
### Treatment

**Acute**

- **gliclazide**: 40-80 mg orally once daily initially, increase according to response, maximum 320 mg/day

**Secondary options**

- **metformin**: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily
  
- **repaglinide**: 0.5 to 1 mg orally up to four times daily initially, increase by 0.5 to 1 mg/day increments every week, maximum 4 mg four times daily
- **nateglinide**: 60-120 mg orally three times daily initially

- Choice of agents should be individualised.

  - Sulfonylureas (e.g., glimepiride, glipizide, gliclazide) enhance the release of insulin by pancreatic islet cells by altering potassium and sodium influx.

  - Sulfonylureas may reduce HbA1c by 10-20 mmol/mol (1% to 2%). Hypoglycaemia is a major concern, especially in patients with irregular or unpredictable eating and exercise habits. Hypoglycaemia risk is exacerbated by alcohol, salicylates, sulphonamides, gemfibrozil, or warfarin. In general, longer-acting sulfonylureas such as glibenclamide are avoided because of concern about hypoglycaemia.

  - In older adult patients, treatment should start with very low doses. Glimepiride may be the preferred sulfonylurea in older individuals, due to its dual hepatic/renal clearance and potentially lower risk of hypoglycaemia.

  - Sulfonylureas can also be given as first-line oral agents when metformin is not tolerated or is contraindicated.

  - Meglitinides (e.g., repaglinide, nateglinide) are an alternative to sulfonylureas, and can also be used as a first-choice secretagogue in people with known allergy to sulphur-containing drugs. Meglitinides have a modest effect on HbA1c, with an average reduction of only 5 mmol/mol (0.5%), but may help with postprandial hyperglycaemia. May cause hypoglycaemia; if a meal is skipped, the dose of meglitinide should be held to avoid hypoglycaemia.
<table>
<thead>
<tr>
<th>Acute</th>
<th></th>
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<tbody>
<tr>
<td>» General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29][62]</td>
<td></td>
</tr>
<tr>
<td>» Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.</td>
<td></td>
</tr>
<tr>
<td>1st basal insulin added to continued metformin + continued cardiovascular risk reduction/lifestyle measures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary options</td>
</tr>
<tr>
<td>» metformin: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily</td>
<td></td>
</tr>
<tr>
<td>AND--</td>
<td></td>
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<tr>
<td>» insulin isophane human (NPH): injected subcutaneously, usually at bedtime</td>
<td></td>
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<tr>
<td><del>or</del></td>
<td></td>
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<tr>
<td>» insulin glargine: injected subcutaneously, usually at bedtime</td>
<td></td>
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<tr>
<td><del>or</del></td>
<td></td>
</tr>
<tr>
<td>» insulin detemir: injected subcutaneously, usually at bedtime</td>
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<tr>
<td><del>or</del></td>
<td></td>
</tr>
<tr>
<td>» insulin degludec: injected subcutaneously once daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Choice of agents should be individualised. Basal insulin is generally added to metformin, usually at bedtime.</td>
</tr>
<tr>
<td></td>
<td>Insulin is necessary treatment in at least 20% to 30% of those with type 2 diabetes in order to achieve recommended treatment goals, related to decreasing islet cell insulin secretion after long duration of type 2 diabetes.</td>
</tr>
<tr>
<td></td>
<td>Patients should perform periodic home glucose monitoring and be instructed to watch for signs of hypoglycaemia (shaking, sweating, intensive hunger, irritability, weakness, confusion) and promptly treat with 15-20 g glucose orally. Recurrent severe hypoglycaemia requires ongoing close monitoring and adjustment of eating and medicine to prevent recurrence.</td>
</tr>
</tbody>
</table>
|                                                                 | Treatment with basal insulin can be started with 0.1 units/kg/dose subcutaneously at bedtime and increase by 2 to 3 units every several days until morning fasting blood glucose averages 5.0 to 7.2 mmol/L (90-130 mg/dL) (for those with a HbA1c goal of <53 mmol/
### Acute

mol [<7%]). Referral to a consultant should be considered for further guidance if the patient is having difficulty achieving blood glucose levels or experiencing symptoms of hyper- or hypoglycaemia.

» In obese patients, who typically are insulin-resistant, 5% to 10% increases in insulin dose every 3 to 5 days are often needed until glucose control is achieved, while taking care to avoid hypoglycaemia. As insulin dose increases, sulfonylureas should be tapered, but metformin may be continued. Home glucose readings should be used to guide therapy decisions.

» General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]

» Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.

### 2nd alpha-glucosidase inhibitor added to continued metformin + continued cardiovascular risk reduction/lifestyle measures

#### Primary options

» **metformin**: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily

- **AND**-

» **acarbose**: 25 mg orally once daily initially, increase to 25 mg twice daily in 1-2 weeks, then increase to 25 mg three times daily in 1-2 weeks, continue to increase according to response, maximum 50 mg three times daily

- **or**-

» **miglitol**: 25 mg orally once daily initially, increase to 25 mg twice daily in 1-2 weeks, then increase to 25 mg three times daily in 1-2 weeks, continue to increase according to response, maximum 50 mg three times daily

» Choice of agents should be individualised. Alpha-glucosidase inhibitors impede the enzyme needed to split disaccharides into monosaccharides prior to absorption from the gut.

» May be combined with most other classes of glucose-lowering medicine. May be useful in
### Type 2 diabetes in adults

#### Treatment

**Acute**

<table>
<thead>
<tr>
<th>2nd thiazolidinedione added to continued metformin + continued cardiovascular risk reduction/lifestyle measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary options</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>- <strong>metformin</strong>: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily -and-</td>
</tr>
<tr>
<td>- <strong>pioglitazone</strong>: 15 mg orally once daily initially, increase every 6-8 weeks, maximum 45 mg once daily</td>
</tr>
</tbody>
</table>

- Choice of agents should be individualised. The benefits and safety of some agents are much more strongly established than those of other agents, and such data should be strongly considered when selecting treatments.

- Neither pioglitazone nor rosiglitazone confers a mortality benefit. Thiazolidinediones may cause fluid retention and exacerbate heart failure. Pioglitazone may be linked to an increased risk of bladder cancer.[138]

- Thiazolidinediones enhance the action of endogenous or exogenous insulin by acting at PPAR-gamma receptors. The complete mechanism of action is not fully understood. May on average reduce HbA1c 10-15 mmol/mol (1.0% to 1.5%); less than insulin, metformin, or sulfonylureas.

- Rather modest impact on HbA1c, must be taken multiple times a day, and costly. Adverse effects can be minimised by low initial doses and by very slow titration of doses.

- Any episodes of hypoglycaemia must be treated with glucose tablets, because this class of medicine blocks gut absorption of carbohydrates such as sucrose or fructose.

- General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]

- Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.

- Neither pioglitazone nor rosiglitazone confers a mortality benefit. Thiazolidinediones may cause fluid retention and exacerbate heart failure. Pioglitazone may be linked to an increased risk of bladder cancer.[138]
### Acute

- **HbA1c above goal on metformin + either basal insulin or second non-insulin agent**

1st

**individualised augmented regimen + continued cardiovascular risk reduction/lifestyle measures**

- Choice of agents should be tailored to account for patient values and preferences, advantages, and adverse effects. The safety of some agents is much more strongly established than the safety of other agents, and such data should be strongly considered when selecting treatments.

- Metformin serves as the basis for most 3-drug combinations, in the absence of contraindications. Additional agents for 3-drug regimens are selected from the same choices as for 2-drug regimens: sulfonylureas/meglitinides, dipeptidyl-peptidase-4 (DPP-4) inhibitors, glucagon-like peptide-1 (GLP-1) agonists, alpha-glucosidase inhibitors, thiazolidinediones, basal insulin, or sodium-glucose co-transporter 2 (SGLT2) inhibitors. However, evidence and guidelines do not support combining a DPP-4 inhibitor and a GLP-1 agonist in the same regimen, and they are not approved for this purpose.

- The American Diabetes Association has updated its combination injectables algorithm: basal insulin plus GLP-1 agonist, basal insulin plus rapid-acting insulin, or fixed-dose insulin regimens are all alternatives.

- To reduce the risk of hypoglycaemia, a sulfonylurea should be tapered if insulin is started. A reduction in dose of sulfonylurea or insulin or both may be needed when used with a GLP-1 agonist, in order to reduce the risk of hypoglycaemia. A DPP-4 inhibitor (less commonly, a thiazolidinedione, considering risks versus benefit) might be considered as an add-

- Hypoglycaemia is rare unless combined with sulfonylurea or insulin.

- Rosiglitazone has been removed from the European market due to persistent safety concerns. In 2013, the US Food and Drug Administration lifted previous restrictions applied to rosiglitazone in the US.

- General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.

- Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.
### Acute

<table>
<thead>
<tr>
<th>1st</th>
<th>switch to basal-bolus insulin + continued cardiovascular risk reduction/lifestyle measures</th>
</tr>
</thead>
</table>

#### Primary options

- **insulin isophane human (NPH):** injected subcutaneously twice daily
- **insulin neutral:** injected subcutaneously two to three times daily

OR

- **insulin glargine:** injected subcutaneously once daily
- **insulin detemir:** injected subcutaneously twice daily
- **insulin degludec:** injected subcutaneously once daily

---

- **Liraglutide,[128] empagliflozin,[111] or canagliflozin[112] [113] can be considered for those with established cardiovascular disease as these agents have been shown to reduce cardiovascular mortality and all-cause mortality.[2] [131] Semaglutide has shown a reduction in major cardiovascular events, but not in all-cause or cardiovascular mortality.[130]

- The Medicines and Healthcare products Regulatory Agency (MHRA) warns of cases of diabetic ketoacidosis in patients with type 2 diabetes on a combination of a GLP-1 receptor agonist and insulin who had doses of concomitant insulin rapidly reduced or discontinued.[133]

- General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]

- Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.

- On to a metformin/sulfonylurea combination in people at high risk for hypoglycaemia.

- **1st switch to basal-bolus insulin + continued cardiovascular risk reduction/lifestyle measures**

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### Type 2 diabetes in adults

**Treatment**

<table>
<thead>
<tr>
<th>Acute</th>
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<tbody>
<tr>
<td>-or-</td>
</tr>
<tr>
<td>» insulin glulisine: injected subcutaneously pre-meals</td>
</tr>
<tr>
<td>OR</td>
</tr>
<tr>
<td>» insulin isophane human/insulin neutral: (50/50, 70/30) injected subcutaneously twice daily</td>
</tr>
<tr>
<td>OR</td>
</tr>
<tr>
<td>» insulin aspart protamine/insulin aspart: (70/30) injected subcutaneously twice daily</td>
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<tr>
<td>OR</td>
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<tr>
<td>» insulin lispro protamine/insulin lispro: (50/50, 75/25) injected subcutaneously twice daily</td>
</tr>
<tr>
<td>OR</td>
</tr>
<tr>
<td>» insulin degludec/insulin aspart: (70/30) injected subcutaneously once or twice daily with any main meal; administer a rapid- or short-acting insulin at other meals if needed</td>
</tr>
</tbody>
</table>

» Basal-bolus insulin is often used when basal insulin or non-insulin multi-drug regimens fail to control blood sugar. For patients already taking basal insulin, consider starting 3 to 5 units of bolus (short- or rapid-acting) insulin at 1 or more meals. Titrate doses up 2 to 3 units at each meal every few days until desired levels of pre-meal (5.0 to 7.2 mmol/L [90-130 mg/dL]) and bedtime (5.6 to 7.8 mmol/L [100-140 mg/dL]) glucoses are achieved, unless hypoglycaemia supervenes.

» Pre-meal insulin is tailored to anticipated meals as well as to pre-meal glucose testing.

» Insulin dose varies; refer to consultant for guidance on dosage.

» Insulin delivery devices that can be programmed to administer set doses of insulin are now available and may be used by patients to help them achieve glycaemic control.

» Choice of insulin regimen should be individualised. Pre-mixed insulin may start with a total of about 0.3 units/kg/day dose of insulin, with two-thirds dose in the morning and one third in the evening, and titrated up until goals
### Treatment

**Acute**

- are achieved or hypoglycaemia prevents further titration.
  - General nutrition and healthy lifestyle knowledge (including an individualised nutrition and exercise plan) can improve glycaemic control and quality of life.[29] [62]
  - Cardiovascular risk reduction (blood pressure and lipid control, non-smoking, and consideration of antiplatelet therapy) should continue.

 **adjunct continued metformin**

Treatment recommended for SOME patients in selected patient group

**Primary options**

- **metformin**: 500 mg orally (immediate-release) once daily initially, increase by 500 mg/day increments every week, maximum 1000 mg twice daily
  - Metformin can be continued with basal-bolus insulin.
  - Metformin reduces hyperglycaemia by decreasing hepatic gluconeogenesis and glycogenolysis. At maximal effective doses, metformin may reduce HbA1c by 10-20 mmol/mol (1% to 2%). It is rarely associated with weight gain, is inexpensive, and has a beneficial effect on low-density lipoprotein cholesterol.
  - The most common side effects are diarrhoea, gas, and nausea, which can be attenuated by initiating slowly 500 mg orally once a day with a meal, increasing as needed by 500 mg/day every 1 to 2 weeks until full dose of 1000 mg twice a day is reached.
  - Metformin is contraindicated if estimated glomerular filtration rate (eGFR) is <30 mL/minute/1.73 m². It should not be initiated if the eGFR is <45 mL/minute/1.73 m², and for patients taking metformin whose eGFR falls to within the 30-45 mL/minute/1.73 m² range, continued use can be considered with close monitoring of renal function and a dose reduction.[102] [103]
  - Metformin should be stopped before surgery or contrast dye studies with radiographic dye injection until adequate post-event renal function is documented.

**2nd bariatric surgery**
Type 2 diabetes in adults

**Treatment**

<table>
<thead>
<tr>
<th>Acute</th>
</tr>
</thead>
<tbody>
<tr>
<td>➤ Bariatric (also known as metabolic) surgery is an option for type 2 diabetes management in some patients with obesity. Patients must be surgical candidates.</td>
</tr>
<tr>
<td>➤ Bariatric surgery is considered in adults with body mass index (BMI) ≥40 kg/m² (≥37.5 kg/m² for people of Asian-family origin) with any level of glycaemic control and any complexity of glucose-lowering regimen.[2]</td>
</tr>
<tr>
<td>➤ Surgery may also be an option for adults with BMI 35.0 to 39.9 kg/m² (32.5 to 37.4 kg/m² for people of Asian-family origin) with hyperglycaemia inadequately controlled despite lifestyle and optimal medical management, and may be considered for those with BMI 30.0 to 34.9 kg/m² (27.5 to 32.4 kg/m² for people of Asian-family origin) with hyperglycaemia inadequately controlled despite optimal use of oral or injectable medications (including insulin).[2]</td>
</tr>
<tr>
<td>➤ Surgery should be done in a high-volume, experienced centre.[2]</td>
</tr>
</tbody>
</table>

**pregnant**

<table>
<thead>
<tr>
<th>1st</th>
<th>diet + basal-bolus insulin</th>
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<tbody>
<tr>
<td><strong>Primary options</strong></td>
<td></td>
</tr>
<tr>
<td>➤ insulin isophane human (NPH): injected subcutaneously twice daily</td>
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<tr>
<td><strong>—AND—</strong></td>
<td></td>
</tr>
<tr>
<td>➤ insulin neutral: injected subcutaneously two or three times daily</td>
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<td>-or-</td>
<td></td>
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<tr>
<td>➤ insulin lispro: injected subcutaneously pre-meals</td>
<td></td>
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<td>-or-</td>
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<tr>
<td>➤ insulin aspart: injected subcutaneously pre-meals</td>
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</tbody>
</table>

> Good glucose control with HbA1c as close to normal as is safely possible (ideally HbA1c <6.5% [48 mmol/mol]) before conception and during pregnancy optimises maternal and fetal health outcomes.[2] ADA guidelines recommend the following blood glucose targets in pregnant women with pre-existing type 2 diabetes (same as for gestational diabetes): <5.3 mmol/L (<95 mg/dL) fasting and either ≤7.8 mmol/L (≤140 mg/dL) 1-hour postprandially or ≤6.7 mmol/L (≤120 mg/dL) 2-hour postprandially;[2] HbA1c target of 42-48 mmol/mol (6.0% to 6.5%) is recommended; <42 mmol/L (<6%) may be optimal as pregnancy progresses if...
Achievable without hypoglycaemia. Target blood glucose values in pregnant women according to guidelines from the UK National Institute for Health and Care Excellence are, if safely achievable, a preprandial glucose 5.3 mmol/L (95 mg/dL), at 1-hour postprandial glucose below 7.8 mmol/L (140 mg/dL), and at 2-hour postprandial glucose below 6.4 mmol/L (115 mg/dL)\[151\] [Evidence C]

- In clinical practice, insulin is usually used when nutrition therapy fails to achieve these goals. Intermediate-acting (NPH) insulin may be combined with human short-acting or analogue rapid-acting insulin. Long-acting analogue insulins (glargine or detemir) are not approved in pregnancy.

- Retinal examination in those with diabetes prior to pregnancy should be performed prior to and during pregnancy. Diabetes patients who become pregnant require care supervision by a specialised centre whenever possible.

- Patients should monitor blood glucose from 4 to 7 times a day and have the pattern examined every few weeks early in pregnancy so that nutrition content and timing, exercise patterns, and the insulin doses can be modified to achieve optimal control. Pre-meal insulin is tailored to anticipated meals as well as to pre-meal glucose testing.

- Insulin requirements generally increase early in pregnancy, then decrease from about 8 to 16 weeks before rising throughout the rest of the pregnancy.

- Pregnant patients also require individualised dietary counselling and team care.

- Insulin dose varies; refer to consultant for guidance on dosage.
Emerging

Insulin human inhalation powder

Rapid-acting inhaled insulin delivered through the lungs has again been approved by the US Food and Drug Administration (FDA) for use in diabetes. A previous inhaled insulin product was removed from the market, with FDA-mandated screening of users of that earlier inhaled insulin product for lung cancer. Inhaled insulin is not preferred over injectable insulins with more established safety experience.
Recommendations

Monitoring

Optimal diabetes care requires a long-term relationship with the patient, appropriate use of consultants when needed, and regular monitoring and control of blood pressure, HbA1c, tobacco use, and statin/aspirin use. Most patients require diabetes assessments every 3 to 4 months, and some patients may benefit from more frequent (monthly) visits, especially when motivated to improve their care. Use of diabetes educators is recommended, although traditional information-based diabetes patient education mandated by some professional organisations is only moderately effective in randomised studies.[194] [195] A multidisciplinary team with access to nurses, educators, dieticians, clinical pharmacologists, psychologists, and other specialists as needed is recommended. Patient readiness to change is a strong predictor of improved care, and readiness to change may vary across the clinical domains of blood pressure, statin use, aspirin use, glucose, smoking, physical activity, and nutrition. Rapid assessment of readiness to change, and directing care to the domain with maximum potential to change, is advised.[196]

Self-management by regular blood glucose monitoring is not routinely recommended in patients with type 2 diabetes, because it does not significantly improve glycaemic control, health-related quality of life, or hypoglycaemia rates.[2] [197] [198] [Evidence C] However, self-monitoring of blood glucose is recommended for those who (a) are on insulin; (b) have had prior hypoglycaemic episodes; (c) drive or operate machinery and use oral medications that increase his or her risk of hypoglycaemia; or (d) are pregnant, or planning to become pregnant.[198]

In addition to care required to achieve recommended levels of blood pressure, statin use, aspirin use, tobacco non-use, and glucose control, the following periodic monitoring for complications is advised:

- Dilated eye examination every 1 to 2 years
- Annual assessment of renal function including both a urinary albumin excretion test and a serum creatinine test with estimated glomerular filtration rate (eGFR) based on the CKD-EPI creatinine equation or equivalent
- Annually or more frequent foot examinations including assessment of ankle reflexes, dorsalis pedis pulse, vibratory sensation, and 10-gram monofilament touch sensation. All patients with insensate feet, foot deformities, or a history of foot ulcers should have their feet examined at every visit and are candidates for specialised footwear.[2]

Due to disease progression, comorbidities, and non-adherence to lifestyle or medication, a substantial fraction of patients who achieve recommended goals for HbA1c, blood pressure, and lipid management relapse to uncontrolled states of one or more of these within 1 year. Relapse is usually asymptomatic; frequent monitoring of clinical parameters is desirable to anticipate or detect relapse early and adjust therapy.

Factors that may lead to loss of adequate glycaemic control include medication non-adherence, depression, musculoskeletal injury or worsening arthritis, competing illnesses perceived by the patient as more serious than diabetes, social stress at home or at work, substance abuse, occult infections, use of medications (such as corticosteroids, certain depression medications [paroxetine], mood stabilisers, or atypical antipsychotics) that elevate weight or glucose, or other endocrinopathies such as Cushing’s disease.

Loss of control of blood pressure and lipids is also a common phenomenon. Close monitoring of patients with diabetes through frequent visits and lab work helps to maintain patients at treatment goals and proactively identify upward trends in blood pressure or HbA1c, and to reinforce the importance of statin adherence and non-smoking.
Patient instructions

- Patients should be advised that frequent medication adjustments represent good care, and are not a sign of failure or a reason for self-blame or guilt.
- The use of self-monitoring of blood glucose data to promptly identify loss of glucose control and proactively adjust therapy is an essential self-management skill when using multi-dose insulin regimens, and requires patient education and easy access to health team members between scheduled surgery visits. Those on multi-dose insulin regimens are often advised to use continuous glucose monitoring (CGM) equipment, or to monitor blood sugars before meals and at bedtime.
- In other patients with diabetes, self-monitoring may be useful to assess the impact of changes in diet, medication regimen, and exercise, as well as to guide dietary and fluid intake and medication management during episodes of illness.[197] [199]
- All women of childbearing age with diabetes should be counselled about the importance of strict glycaemic control prior to conception.[2]
- Patients should receive counselling on how to prevent and promptly identify eye, foot, kidney, and cardiovascular complications.
- Patients should be advised that low blood sugar (glucose ≤3.9 mmol/L [≤70 mg/dL]) is often accompanied by symptoms such as tachycardia, sweating, shakiness, intense hunger, or confusion, and must be dealt with promptly by ingesting 15-20 g of carbohydrate (equivalent to 3 to 4 glucose tablets of 5 grams per tablet). After self-treatment, blood sugar should be checked if possible. Instruct patients to promptly report nocturnal hypoglycaemia or recurrent episodes of hypoglycaemia so that therapy may be adjusted. Patients should have a carbohydrate snack prior to exercise if self-monitored blood glucose is <5.6 mmol/L (<100 mg/dL) and the patient is taking insulin or an insulin secretagogue (sulfonylurea or meglitinide). Patients using alpha-glucosidase inhibitors who experience hypoglycaemia must use glucose tablets because absorption of conventional carbohydrates is slowed by the treatment.[2] Those at risk of clinically significant hypoglycaemia (glucose <3.0 mmol/L [<54 mg/dL]) should have injectable glucagon available, and a close companion should be instructed on how to inject glucagon.[2]
Complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Timeframe</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>diabetic kidney disease</td>
<td>long term</td>
<td>low</td>
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</tbody>
</table>
| Chronic kidney disease occurs in about 40% of patients with type 2 diabetes over time. Prevalence of end-stage renal disease is about 1% in those with type 2 diabetes (cross-sectional data).[172] Chronic kidney disease is driven by uncontrolled blood pressure and glucose, and increases the risk of cardiovascular disease at least fourfold. An estimated glomerular filtration rate (eGFR) <60 mL/1.73m²/minute establishes a diagnosis of chronic kidney disease, and microalbuminuria or albuminuria establishes a diagnosis of nephropathy. Either of these findings should prompt increased efforts to aggressively manage systolic blood pressure, avoid non-steroidal anti-inflammatory drugs (NSAIDs), and consider use of antihyperglycaemic drugs with low risk of hypoglycaemia and pronounced renal benefits (such as sodium-glucose co-transporter 2 [SGLT2] inhibitors or glucagon-like peptide-1 [GLP-1] agonists).[106][127]
Also important are use of an ACE inhibitor or angiotensin-II receptor antagonist, and optimisation of glucose control. When eGFR is lower than 30 mL/minute/1.73m², referral to a nephrologist for expectant management of end-stage renal disease is necessary.
Renal failure predisposes patients to anaemia and hypoglycaemia; in renal failure, insulin doses may need to be reduced.

<table>
<thead>
<tr>
<th>impaired vision</th>
<th>long term</th>
<th>low</th>
</tr>
</thead>
</table>
| In the US, approximately 25% of patients with type 2 diabetes have retinopathy at diagnosis, presumably as a consequence of unrecognised disease.[182] In a global study, prevalence of diabetic retinopathy in newly diagnosed type 2 diabetes varied from 1.5% to 31%, with higher prevalence observed in developing countries.[183] Risk of vision loss is increased by poor blood pressure and glucose control, and by failure to regularly screen for retinopathy, macular degeneration, glaucoma, and cataracts.[184][185] The risk of all of these eye conditions is increased in diabetes.

<table>
<thead>
<tr>
<th>lower extremity amputation</th>
<th>long term</th>
<th>low</th>
</tr>
</thead>
</table>
| Incidence of lower extremity amputation (LEA) is between 2.5 and 4 per 1000 people with diabetes per year, with significant geographic variation in LEA rates within countries.[186] Incidence rates of major LEA, defined as loss of lower limb through or above the ankle, are declining in patients with diabetes; however, there is some evidence that minor LEA (loss of lower limb below the level of the ankle) incidence rates are increasing, with about half being toe or metatarsal amputations.[170]
Risk is aggravated by neuropathy and by peripheral vascular disease, and can be reduced by smoking cessation; aggressive management of glucose, blood pressure, and lipids; use of customised footwear in patients with known neuropathy or foot deformity; and prompt and aggressive management of lower extremity infections.

<table>
<thead>
<tr>
<th>cardiovascular disease</th>
<th>variable</th>
<th>high</th>
</tr>
</thead>
</table>
| Cardiovascular disease (CVD) and CVD-associated mortality is declining in patients with diabetes, particularly in high-income countries.[170] Adults with type 2 diabetes are twice as likely to die of stroke or myocardial infarction compared with those without diabetes, and they are more than 40 times more likely to die of macrovascular than to die of microvascular complications of diabetes.[65][66] To reduce cardiovascular risk, blood pressure, lipids, and tobacco use should be adequately managed. Use of statins, ACE inhibitors, metformin, aspirin, empagliflozin, liraglutide, and proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors may reduce cardiovascular mortality or all-cause mortality in selected...
**Type 2 diabetes in adults**

### Complications

<table>
<thead>
<tr>
<th></th>
<th>Timeframe</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>patients with type 2 diabetes. In the ACCORD and ADVANCE randomized trials, near-normal glucose control failed to decrease cardiovascular mortality or all-cause mortality in type 2 diabetes, and in one of those studies, increased all-cause mortality. However, ACCORD and ADVANCE trials did not use empagliflozin, liraglutide, or PCSK9 inhibitors. Many studies suggest that HbA1c ≥64 mmol/mol (≥8%) increases risk of major cardiovascular events.[97] [98]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased fatigability may be an early warning sign of progressive cardiovascular disease; clinicians should have a low threshold for cardiac evaluation of any symptoms that are potentially cardiac-related in patients with type 2 diabetes.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### congestive heart failure (CHF)

<table>
<thead>
<tr>
<th></th>
<th>variable</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes is a risk factor for CHF, with poor glycaemic control associated with greater risk for the development of CHF and worsening of clinical outcomes for patients with CHF and diabetes.[174] CHF occurs in up to 10% to 15% of patients with diabetes.[175] CHF in type 2 diabetes is often related to uncontrolled hypertension, or ischaemic coronary disease, but may also occur as a microvascular complication of diabetes.</td>
<td></td>
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<tr>
<td>Requires management with ACE inhibitor/angiotensin-II receptor antagonist, diuretics, and other medications.</td>
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<tr>
<td>Must rule out underlying causes such as myocardial infarction, atrial fibrillation, thyroid disorders, anaemia, or structural heart disease.</td>
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</tbody>
</table>

#### stroke

<table>
<thead>
<tr>
<th></th>
<th>variable</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related to uncontrolled blood pressure, glucose, and lipids. Lifetime risk is higher in women than in men with diabetes.[176]</td>
<td></td>
<td></td>
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<tr>
<td>Prompt hospitalisation and neurological evaluation, with possible emergency use of tissue plasminogen activator (TPA) or other therapeutic strategies, may minimise damage and maximise potential for recovery of function.</td>
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</tbody>
</table>

#### infection

<table>
<thead>
<tr>
<th></th>
<th>variable</th>
<th>medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperglycaemia compromises defence against bacterial infections by several mechanisms including impaired phagocytosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normalisation of blood glucose reduces the risk of infections, especially cystitis, cellulitis, and pneumonia. Immunisation reduces the risk of serious pneumococcal, <em>Haemophilus influenzae</em>, and influenza infections.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggressive infection-specific therapy and supportive therapy including adequate glucose control are key to successful treatment.</td>
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<td></td>
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</tbody>
</table>

#### periodontal disease

<table>
<thead>
<tr>
<th></th>
<th>variable</th>
<th>medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 2 diabetes is associated with periodontal disease, but causality is not established.[177] In one large epidemiological survey, periodontal disease was an independent predictor of incident diabetes.[177] Bidirectional risk has been postulated.[178]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control of periodontal disease and hyperglycaemia are mutually beneficial. Routine preventative dental care is important for people with type 2 diabetes.[177]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Complications | Timeframe | Likelihood
--- | --- | ---
treatment-related hypoglycaemia | variable | medium

Related to treatment with insulin and/or insulin secretagogues (sulfonylureas or meglitinides), alone or in combination with other drugs. A glucose alert value is defined as ≤3.9 mmol/L (≤70 mg/dL), requiring treatment with fast-acting carbohydrate and dose adjustment of glucose-lowering therapy. Clinically significant hypoglycaemia is defined as <3.0 mmol/L (<54 mg/dL), indicating serious, clinically important hypoglycaemia.[2] Low blood sugars are common in patients who are trying to achieve HbA1c <53 mmol/mol (<7%). Hypoglycaemia is usually associated with warning signs, such as rapid heartbeat, perspiration, shakiness, anxiety, confusion, and hunger. Hypoglycaemia unawareness (absence of symptoms during hypoglycaemia) and severe hypoglycaemia, defined as a blood sugar so low that assistance from another person or medical personnel is required to treat it, occurs in 1% to 3% of type 2 diabetes patients per year. Older people and those with comorbid heart disease, congestive heart failure, chronic kidney disease, or depression are at substantially increased risk for severe hypoglycaemia.[179]

Patients should be counselled on recognition, prevention, and treatment of hypoglycaemia and should carry with them glucose tablets or comparable 20 g fast-acting carbohydrate product. Patients using alpha-glucosidase inhibitors must use glucose tablets for hypoglycaemia because absorption of conventional carbohydrates is slowed by the medication.

depression | variable | medium

When glycaemic goals or adherence to treatment plan are difficult to achieve, the presence of depression should be considered. Screening with a validated tool such as the Patient Health Questionnaire (PHQ)-9 may help with identification and diagnosis. The cross-sectional prevalence of depression is 10% to 25% in people with diabetes.[189] Adults with type 2 diabetes diagnosed before age 40 years have excess hospitalisations across their lifespan, which includes a large burden of mental illness in young adulthood.[190]

obstructive sleep apnoea | variable | medium

Obstructive sleep apnoea is common among overweight and obese adults, and has been associated with insulin resistance and altered glucose metabolism. Further studies are needed to assess the effect of continuous positive airway pressure (CPAP) on glycaemic control, as results have varied.[191] [192] [193]

The American Diabetes Association recommends assessment of sleep pattern and duration as part of a comprehensive approach to lifestyle and glycaemic control.[2]

diabetic ketoacidosis | variable | low

Commonly thought of in type 1 diabetes; however, can occur in type 2 diabetes and an unusual type of diabetes known as ketosis-prone diabetes. Infection and poor diabetic medication adherence are the most common reasons for developing diabetic ketoacidosis, but no precipitating factors may be apparent.[180]

Criteria of diabetic ketoacidosis is the same, regardless of type of diabetes and is potentially fatal if not properly treated.

Hydration, parenteral insulin therapy, intensive monitoring, and careful management of electrolyte imbalances and acidosis are important for successful therapy.

non-ketotic hyperosmolar state | variable | low

Occurs most commonly in older people with type 2 diabetes and usually evolves insidiously over days to weeks.[181] Characterised by severe hyperglycaemia, hyperosmolarity, and volume depletion, in the absence of severe ketoacidosis.
Complications | Timeframe | Likelihood
--- | --- | ---
Hydration, insulin therapy, and careful clinical and laboratory monitoring are the basis of successful therapy.

**autonomic or peripheral neuropathy** | variable | low

Diabetic peripheral neuropathy is the most common chronic complication of diabetes, characterised by the presence of peripheral nerve dysfunction, diagnosed after the exclusion of other causes.[187] Pain is the outstanding complaint in most patients, but many patients are completely asymptomatic.

Manifestations of autonomic neuropathy may include: erectile dysfunction, diarrhoea, gastroparesis, or orthostatic hypotension.

For type 2 diabetes the effects of glycaemic control on peripheral or autonomic neuropathy are less clear than for type 1 diabetes, with early data suggesting that glucose control is beneficial if started earlier in the disease course, but later studies not confirming these findings.[188]

### Prognosis

Diabetes increases the likelihood of major cardiovascular events and death, but the increased risk is variable across patients depending on age at diabetes onset, duration of diabetes, glucose control, blood pressure control, lipid control, tobacco control, renal function, microvascular complication status, and other factors. The association of diabetes and increased mortality can be attenuated by cardiovascular risk factor control.[169] A HbA1c of 6% to 6.9% (42 mmol/mol to 52 mmol/mol) is associated with the lowest mortality.[169] Trends in data for complications in people with diabetes show a declining risk of cardiovascular disease (CVD) and CVD-associated mortality, particularly in high-income countries.[170] When type 2 diabetes is diagnosed at age 40, men lose an average of 5.8 years of life, and women lose an average of 6.8 years of life.[10] The overall excess mortality in those with type 2 diabetes is around 15% higher, but ranges from ≥60% higher in younger adults with poor glucose control and impaired renal function, to better than those without diabetes for those who are age 65 and over with good glucose control and no renal impairment.[65] [66]

Cumulative prevalence of vision-threatening diabetic retinopathy in the US is about 4.4% among adults with type 2 diabetes, and appears to be higher for non-Hispanic black people compared with non-Hispanic white people (9.3% vs. 3.2%, respectively).[171] Prevalence of end-stage renal disease (ESRD) is about 1% in those with type 2 diabetes (cross-sectional data), but cumulative prevalence of nephropathy and/or chronic kidney disease is much higher.[172] Incidence rates of ESRD attributed to diabetes are declining; however, continued intervention to detect and manage diabetic kidney disease is required to limit the development of ESRD.[173] Effective treatment requires a motivated and informed patient who actively takes responsibility for the care of his or her diabetes, and a clinical team willing to frequently adjust medications to support comprehensive disease management over a long period of time.
# Diagnostic guidelines

## Europe

**Guidelines on diabetes, pre-diabetes, and cardiovascular diseases**  
*Published by:* European Society of Cardiology (ESC); European Association for the Study of Diabetes (EASD)  
*Last published:* 2019

**Type 2 diabetes in adults: management**  
*Published by:* National Institute for Health and Care Excellence  
*Last published:* 2019

**Type 2 diabetes: prevention in people at high risk**  
*Published by:* National Institute for Health and Care Excellence  
*Last published:* 2017

**Diabetes in pregnancy: management from preconception to the postnatal period**  
*Published by:* National Institute for Health and Care Excellence  
*Last published:* 2015

## International

**Managing type 2 diabetes in primary care**  
*Published by:* International Diabetes Foundation  
*Last published:* 2017

**Managing older people with type 2 diabetes: global guidelines**  
*Published by:* International Diabetes Foundation  
*Last published:* 2013
## North America

### Standards of medical care in diabetes - 2019
- **Published by:** American Diabetes Association
- **Last published:** 2019

### Primary prevention of ASCVD and T2DM in patients at metabolic risk
- **Published by:** Endocrine Society
- **Last published:** 2019

### Treatment of diabetes in older adults
- **Published by:** Endocrine Society
- **Last published:** 2019

### Guideline on the primary prevention of cardiovascular disease
- **Published by:** American College of Cardiology; American Heart Association
- **Last published:** 2019

### Guideline on the management of blood cholesterol
- **Published by:** American Heart Association; American College of Cardiology
- **Last published:** 2019

### Diabetes Canada clinical practice guidelines
- **Published by:** Diabetes Canada
- **Last published:** 2018

### Guideline for the prevention, detection, evaluation, and management of high blood pressure in adults
- **Published by:** American College of Cardiology; American Heart Association
- **Last published:** 2017

### Abnormal blood glucose and type 2 diabetes mellitus: screening
- **Published by:** US Preventive Services Task Force
- **Last published:** 2015
# Treatment guidelines

## Europe

### Guidelines on diabetes, pre-diabetes, and cardiovascular diseases
- **Published by:** European Society of Cardiology
- **Last published:** 2019

### Type 2 diabetes in adults: management
- **Published by:** National Institute for Health and Care Excellence
- **Last published:** 2019

### Diabetic foot problems: prevention and management
- **Published by:** National Institute for Health and Care Excellence
- **Last published:** 2019

### Community pharmacies: promoting health and wellbeing
- **Published by:** National Institute for Health and Care Excellence
- **Last published:** 2018

### Pharmacological management of glycaemic control in people with type 2 diabetes (SIGN 154)
- **Published by:** Scottish Intercollegiate Guidelines Network
- **Last published:** 2017

### Management of diabetes (SIGN 116)
- **Published by:** Scottish Intercollegiate Guidelines Network
- **Last published:** 2017

### Diabetes in pregnancy: management from preconception to the postnatal period
- **Published by:** National Institute for Health and Care Excellence
- **Last published:** 2015

## International

### Guidelines on second- and third-line medicines and type of insulin for the control of blood glucose levels in non-pregnant adults with diabetes mellitus
- **Published by:** World Health Organization
- **Last published:** 2018

### Managing type 2 diabetes in primary care
- **Published by:** International Diabetes Foundation
- **Last published:** 2017

### The Diabetes Surgery Summit II guidelines: a disease-based clinical recommendation
- **Published by:** The Second Diabetes Surgery Summit
- **Last published:** 2016

### Managing older people with type 2 diabetes: global guidelines
- **Published by:** International Diabetes Foundation
- **Last published:** 2013
## North America

### Standards of medical care in diabetes - 2019

**Published by:** American Diabetes Association  
**Last published:** 2019

### Treatment of diabetes in older adults

**Published by:** Endocrine Society  
**Last published:** 2019

### Guideline on the management of blood cholesterol

**Published by:** American Heart Association; American College of Cardiology  
**Last published:** 2019

### Diabetes Canada clinical practice guidelines

**Published by:** Diabetes Canada  
**Last published:** 2018

### Oral pharmacologic treatment of type 2 diabetes mellitus: a clinical practice guideline update

**Published by:** American College of Physicians  
**Last published:** 2017
### Evidence tables

**What are the optimal target values for blood glucose in pregnant women with gestational or pre-gestational diabetes?**\[151\]

This table is a summary of the analysis reported in a guideline (underpinned by a systematic review) that focuses on the above important clinical question.

### View the full source guideline

Confidence in the evidence is very low or low where GRADE has been performed and the intervention may be more effective/beneficial than the comparison for key outcomes. However, this is uncertain and new evidence could change this in the future.

**Population:** Pregnant women with type 1, type 2, or gestational diabetes  
**Intervention:** Lower blood glucose target  
**Comparison:** Higher blood glucose target

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effectiveness (BMJ rating)[Ev2]</th>
<th>Confidence in evidence (GRADE)[Ev3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting blood glucose &lt;5.3 mmol/L versus ≥5.3 mmol/L in women with gestational diabetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-eclampsia</td>
<td>Favours intervention</td>
<td>Very Low</td>
</tr>
<tr>
<td>Large for gestational age</td>
<td>Favours intervention</td>
<td>Very Low</td>
</tr>
<tr>
<td>1-2 hour post-prandial blood glucose ≤7.8 mmol/L versus &gt;7.8 mmol/L in women with pre-gestational diabetes (white class diabetes B to RF [see classification section in the BMJ Best Practice Gestational Diabetes topic])</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macrosomia at 29-32 weeks’ gestation</td>
<td>Favours intervention</td>
<td>Very Low</td>
</tr>
<tr>
<td>2 hour post-prandial blood glucose &lt;6.4 mmol/L versus ≥6.4 mmol/L in women with gestational diabetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-eclampsia</td>
<td>Favours intervention</td>
<td>Very Low</td>
</tr>
<tr>
<td>Large for gestational age</td>
<td>Favours intervention</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

**Recommendations as stated in the source guideline**
The guideline committee states that pregnant women with any form of diabetes should maintain their capillary plasma glucose levels below 5.3 mmol/L (fasting), 7.8 mmol/L (1 hour after meals), or 6.4 mmol/L (2 hours after meals), if achievable without causing problematic hypoglycaemia.
What are the effects of self-management by regular blood glucose monitoring in people with type 2 diabetes?\[198\]

This table is a summary of the analysis reported in a guideline (underpinned by a systematic review) that focuses on the above important clinical question.

**Evidence C** \[^{[Ev1]}\] Confidence in the evidence is very low or low where GRADE has been performed and there is a trade off between benefits and harms of the intervention.

**Population:** People with type 2 diabetes  
**Intervention:** Self-monitoring blood glucose  
**Comparison:** No self-monitoring blood glucose (including usual care and self-monitoring of urine glucose)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effectiveness (BMJ rating) [^{[Ev2]}]</th>
<th>Confidence in evidence (GRADE) [^{[Ev3]}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin A1c (HbA1c) (follow up: 24-52 weeks)</td>
<td>Favours intervention</td>
<td>Low</td>
</tr>
<tr>
<td>Fasting blood glucose (mmol/L) (follow up: 26-52 weeks)</td>
<td>Favours intervention</td>
<td>Low</td>
</tr>
<tr>
<td>Post-prandial blood glucose (mg/dL) at 26 weeks for adults with type 2 diabetes on diet, anti-diabetic, and/or insulin medicines (follow up: 6 months)</td>
<td>Favours intervention</td>
<td>Low</td>
</tr>
<tr>
<td>Any hypoglycaemia from 26-52 weeks (follow up: 6-12 months)</td>
<td>Favours comparison</td>
<td>Low</td>
</tr>
<tr>
<td>Severe hypoglycaemia from 26-52 weeks (follow up: 6-12 months)</td>
<td>No statistically significant difference</td>
<td>Low</td>
</tr>
<tr>
<td>Adverse events at 6 months for adults with type 2 diabetes on oral anti-diabetes medicines (follow up: 6 months)</td>
<td>No statistically significant difference</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
**Recommendations as stated in the source guideline**
The guideline development group states: do not routinely offer self-monitoring of blood glucose levels for adults with type 2 diabetes unless:

- the person is on insulin or
- there is evidence of hypoglycaemic episodes or
- the person is on oral medication that may increase their risk of hypoglycaemia while driving or operating machinery or
- the person is pregnant, or is planning to become pregnant.

**Note**
The guideline development group noted that self-monitoring of blood glucose provides the potential for tight glycaemic control which reduces the risk of diabetes-related complications. However, the impact on hypoglycaemic events is important in determining the safety and acceptability in patients.
**Ev1. Evidence levels**

The Evidence level is an internal rating applied by BMJ Best Practice. See the EBM Toolkit for details.

**Confidence in evidence**

A - High or moderate to high  
B - Moderate or low to moderate  
C - Very low or low

**Ev2. Effectiveness (BMJ rating)**

Based on statistical significance, which demonstrates that the results are unlikely to be due to chance, but which does not necessarily translate to a clinical significance.

**Ev3. Grade certainty ratings**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>The authors are very confident that the true effect is similar to the estimated effect.</td>
</tr>
<tr>
<td>Moderate</td>
<td>The authors are moderately confident that the true effect is likely to be close to the estimated effect.</td>
</tr>
<tr>
<td>Low</td>
<td>The authors have limited confidence in the effect estimate and the true effect may be substantially different.</td>
</tr>
<tr>
<td>Very Low</td>
<td>The authors have very little confidence in the effect estimate and the true effect is likely to be substantially different.</td>
</tr>
</tbody>
</table>

BMJ Best Practice EBM Toolkit: What is GRADE?
Key articles


References


Type 2 diabetes in adults


Type 2 diabetes in adults

References


Type 2 diabetes in adults


103. US Food and Drug Administration. FDA drug safety communication: FDA revises warnings regarding use of the diabetes medicine metformin in certain patients with reduced kidney function. Apr 2016 [internet publication]. Full text


<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>117.</td>
<td>ClinicalTrials.gov. ERtugliflozin triAl in DIabetes With Preserved or Reduced ejeCtion FrAcTion mEchanistic Evaluation in Heart Failure (ERADICATE-HF). NCT03416270. May 2018 [internet publication]. [Full text]</td>
</tr>
<tr>
<td>118.</td>
<td>US Food and Drug Administration (FDA). FDA drug safety communication: FDA strengthens kidney warnings for diabetes medicines canagliflozin (Invokana, Invokamet) and dapagliflozin (Farxiga, Xigduo XR). Jun 2016 [internet publication]. [Full text]</td>
</tr>
<tr>
<td>120.</td>
<td>US Food and Drug Administration (FDA). FDA drug safety communication: FDA confirms increased risk of leg and foot amputations with the diabetes medicine canagliflozin (Invokana, Invokamet, Invokamet XR). May 2017 [internet publication]. [Full text]</td>
</tr>
<tr>
<td>121.</td>
<td>European Medicines Agency (EMA). SGLT2 inhibitors: information on potential risk of toe amputation to be included in prescribing information. Feb 2017 [internet publication]. [Full text]</td>
</tr>
</tbody>
</table>

123. US Food and Drug Administration (FDA). FDA drug safety communication: FDA warns about rare occurrences of a serious infection of the genital area with SGLT2 inhibitors for diabetes. Aug 2018 [internet publication]. Full text


133. Medicines and Healthcare products Regulatory Agency. GLP-1 receptor agonists: reports of diabetic ketoacidosis when concomitant insulin was rapidly reduced or discontinued. Jun 2019 [internet publication]. Full text


138. US Food and Drug Administration. FDA drug safety communication: updated FDA review concludes that use of type 2 diabetes medicine pioglitazone may be linked to an increased risk of bladder cancer. Dec 2016 [internet publication].  Full text


<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>165.</td>
<td>US Food and Drug Administration (FDA). Information for consumers (drugs): use of aspirin for primary prevention of heart attack and stroke. May 2014 [internet publication].</td>
</tr>
<tr>
<td>166.</td>
<td>US Food and Drug Administration (FDA). FDA drug safety communication: FDA revises labels of SGLT2 inhibitors for diabetes to include warnings about too much acid in the blood and serious urinary tract infections. Dec 2015 [internet publication].</td>
</tr>
</tbody>
</table>
| 174. | Dunlay SM, Givertz MM, Aguilar D, et al. Type 2 diabetes mellitus and heart failure: a scientific statement from the American Heart Association and the Heart Failure Society of America. This
Type 2 diabetes in adults


Type 2 diabetes in adults


Figure 1: Acanthosis nigricans involving the axilla

From the collection of Melvin Chiu, MD; used with permission
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Please note that recommended formulations and doses may differ between drug databases drug names and brands, drug formularies, or locations. A local drug formulary should always be consulted for full prescribing information.

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Where your version of BMJ Best Practice does not integrate with a local drug formulary, you should consult a local pharmaceutical database for comprehensive drug information including contraindications, drug interactions, and alternative dosing before prescribing.

Interpretation of numbers

Regardless of the language in which the content is displayed, numerals are displayed according to the original English-language numerical separator standard. For example 4 digit numbers shall not include a comma nor a decimal point; numbers of 5 or more digits shall include commas; and numbers stated to be less than 1 shall be depicted using decimal points. See Figure 1 below for an explanatory table.

BMJ accepts no responsibility for misinterpretation of numbers which comply with this stated numerical separator standard.

This approach is in line with the guidance of the International Bureau of Weights and Measures Service.

Figure 1 – BMJ Best Practice Numeral Style