Diabetes mellitus (DM) is characterised by organ dysfunction arising directly or indirectly from the effects of chronic hyperglycaemia. The chronic complications of diabetes are traditionally classified as macro- or microvascular depending on the underlying pathophysiology. The microvascular triad of retinopathy, nephropathy and neuropathy is unique to diabetes. Most patients with diabetes will have one or more of these as overt or subclinical manifestations during the course of their disease. This review aims to give a broad overview of diabetes-related microvascular disease.

Pathophysiology

The underlying driver of microvascular disease is tissue exposure to chronic hyperglycaemia. Landmark clinical trials such as the UK Prospective Diabetes Study (UKPDS) and Diabetes Control of Complications Trial (DCCT) have established a clear relationship between microvascular disease and glucose control. Microvascular disease tends to occur predominantly in tissues where glucose uptake is independent of insulin activity (e.g., kidney, retina and vascular endothelium) because these tissues are exposed to glucose levels that correlate very closely with blood glucose levels. The development of disease is the result of a combination of direct glucose-mediated endothelial damage, oxidative stress due to superoxide overproduction, and the production of sorbitol and advanced glycation end-products due to the prevailing state of hyperglycaemia. These metabolic injuries cause altered blood flow and changes in endothelial permeability, extravascular protein deposition and coagulation resulting in organ dysfunction. Current evidence demonstrates a clear relationship between blood pressure (BP) and progression of nephropathy and retinopathy. These are now established as independent risk factors for microvascular disease progression.

Diabetic retinopathy

Diabetic retinopathy is the most common cause of visual loss in working-age adults in the developed world. It occurs following hyperglycaemia-mediated damage within the retinal microvasculature. This damage causes basement membrane thickening, increased capillary permeability and the formation of microaneurysms. These changes lead to intravascular coagulation, resulting in retinal ischaemia which drives the formation of new vessels within the retina (neovascularisation). These new vessels are fragile and may rupture causing retinal bleeds. Furthermore, the lack of lymphatic drainage within the retina causes fluid accumulation in the presence of hyperglycaemia resulting in macular oedema. Macular oedema can be associated with any of the aforementioned stages. The classification of different forms of retinopathy is given in Table 1.

The UKPDS trial highlighted that up to 40% of patients with type 2 diabetes (T2DM) have some retinopathy at the time of diagnosis, reflecting late presentation in this group. This contrasts with epidemiological data in which the prevalence varies from 16–95% depending on duration of diabetes. Diabetic retinopathy is rare in newly diagnosed patients with T1DM where the presentation is more acute. Diabetes duration, glycaemic control and BP are the strongest risk factors for the development and progression of retinopathy. There is some evidence that rapid improvements in glycaemic control can cause transient worsening of retinopathy. In patients with advanced retinopathy improvements in glycaemic control should therefore be gradual. Retinopathy is known to deteriorate during pregnancy; these patients need to have retinal assessments soon after their first appointment and again in the 28th week of pregnancy.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background retinopathy</td>
<td>Microaneurysms (saccular pouches due to capillary distension)</td>
</tr>
<tr>
<td>Pre-proliferative</td>
<td>Dot/blot haemorrhages</td>
</tr>
<tr>
<td></td>
<td>Hard exudates (lipid deposits related to extravascular leaks)</td>
</tr>
<tr>
<td></td>
<td>Venous beading</td>
</tr>
<tr>
<td></td>
<td>Intraretinal microvascular abnormalities</td>
</tr>
<tr>
<td>Proliferative retinopathy</td>
<td>Neovascularisation:</td>
</tr>
<tr>
<td></td>
<td>• new vessel disc</td>
</tr>
<tr>
<td></td>
<td>• new vessel elsewhere</td>
</tr>
<tr>
<td>Advanced eye disease</td>
<td>Vitreous haemorrhage</td>
</tr>
<tr>
<td></td>
<td>Traction retinal detachment</td>
</tr>
<tr>
<td></td>
<td>Ruberosis iridis</td>
</tr>
<tr>
<td></td>
<td>Rubecotic glaucoma</td>
</tr>
<tr>
<td>Maculopathy</td>
<td>Macular oedema</td>
</tr>
<tr>
<td></td>
<td>Hard exudates in macular region</td>
</tr>
</tbody>
</table>

Table 1. Classification of diabetic retinopathy.
Pan-retinal photocoagulation, introduced in the early 1970s, is the treatment of choice for proliferative and pre-proliferative retinopathy. This procedure coagulates the ischaemic retina which acts as the driving factor for new vessel formation (presumably by reducing vascular endothelial growth factor). Focal laser treatment is also used in macular oedema to reduce vascular leakage. Laser treatment can bring down the five-year incidence of blindness from 50% to 5%, but at the expense of losing up to 50% of peripheral vision – with possible implications for driving licence holders.

**Nephropathy**

Diabetic nephropathy arises from the combination of hyperglycaemia and hypertension driving glomerular damage. The underlying pathological changes involve thickening of basement membrane, atrophy, interstitial fibrosis and arteriosclerosis. This initially results in glomerular hyperfiltration and subsequently progressive loss of renal function. Diabetic nephropathy occurs in 30–40% of patients within 25 years. It is not understood why some individuals with ‘poor control’ are protected against renal disease.

**Microalbuminuria**

Increased glomerular filtration pressures result in albuminuria, a marker of vascular endothelial dysfunction and there is a good correlation between cardiovascular risk and degree of albuminuria. The presence of microalbuminuria should therefore prompt clinicians to manage all cardiovascular risk factors aggressively. Criteria for referrals to nephrology services need to be defined so that these patients can be referred in a timely manner and their care optimised.

**Table 2. Overview of the clinical spectrum of diabetic neuropathy.**

<table>
<thead>
<tr>
<th>Type of neuropathy</th>
<th>Clinical phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperglycaemic neuropathy</td>
<td>Reversible, influenced by glucose levels</td>
</tr>
<tr>
<td>Symmetrical sensorimotor neuropathy</td>
<td>Most common presentation, glove and stocking pattern</td>
</tr>
<tr>
<td>Focal neuropathy</td>
<td>Cranial nerve palsies</td>
</tr>
<tr>
<td></td>
<td>Diabetic amyotrophy</td>
</tr>
<tr>
<td>Autonomic neuropathy</td>
<td>Postural hypotension</td>
</tr>
<tr>
<td></td>
<td>Erectile dysfunction</td>
</tr>
<tr>
<td></td>
<td>Gastroparesis</td>
</tr>
<tr>
<td></td>
<td>Gustatory sweating</td>
</tr>
</tbody>
</table>

**Neuropathy**

Diabetic neuropathy refers to a spectrum of various neurological disorders associated with diabetes. Rarely, hyperglycaemia can induce an acute neuropathy that is
reversible when glycaemic control is improved, but neuropathy is usually persistent. The most common form is a distal, symmetrical sensorimotor neuropathy which may be asymptomatic in up to 50%. The spectrum can include a wide range of clinical syndromes (Table 2), including cranial nerve palsies, mononeuropathies and autonomic dysfunction. The main sequel of neuropathy is foot deformity, ulceration and Charcot arthropathy. The combination of neuropathy, arthropathy and infection are the driving factors behind most diabetic foot amputations.

Management

The management of neuropathy is predominantly supportive. Good glycaemic control can reduce its progression. However, once neuropathy has been established glycaemic control has little influence in controlling pain which is the main symptom. Simple analgesics suffice in mild cases of painful neuropathy, but opiates may be required in more severe cases. Amitriptyline, duloxetine, gabapentin and pregabalin all have evidence of being superior to placebo. Tricyclic antidepressants such as amitriptyline are first-line agents but pregabalin is particularly useful as therapeutic benefits are seen early. Clinicians need to have empathy with a holistic approach when dealing with these patients and often high doses of analgesics are needed. Patients with neuropathy need to be told of the importance of paying attention to foot care and wearing appropriate footwear as they are at high risk of developing ulcers. Patients also need to have access to podiatry and chiropody services for regular assessment of their feet.

Severe symptoms. Autonomic neuropathy can have devastating effects on patients’ lives. Postural hypotension increases the risk of falling. Standard treatments such as fludrocortisone are usually not possible due to coexisting hypertension. Gastroparesis can cause intractable nausea and vomiting in severe cases. Delays in food absorption in mild cases cause severe problems in insulin treated patients where erratic food absorption causes fluctuations in blood glucose levels that are difficult to control with conventional basal bolus regimens. In fact, a large proportion of patients with ‘brittle diabetes’ have some degree of underlying gastroparesis. Mild cases can be managed with prokinetic agents such as metoclopramide, domperidone, erythromycin and dietary modification. More severe cases may require gastric electrical stimulation where implanted electrodes act as a form of gastric pacemaker and stimulate gastric contractions. Unfortunately, this procedure is performed only in specialist centres. Erectile dysfunction affects up to 50% of men with diabetes and is often multifactorial (a combination of neuropathy, small vessel disease, medication and psychological), requiring a holistic approach.

Key points

Diabetes is associated with significant microvascular complications: retinopathy, neuropathy and nephropathy

Diabetic retinopathy remains the most common cause of blindness in working-age adults in the developed world.

Early aggressive treatment of microalbuminuria reduces the risk of the development of nephropathy

Neuropathy may manifest in different ways and can be difficult to manage

Prevention and reduction in progression of microvascular complications requires intensive management of glucose, blood pressure and lipids

KEY WORDS: complications, diabetes, management, prevention

Preventing microvascular disease

Risk factors

The prevention of microvascular disease involves paying attention to aggravating risk factors and implementing screening programmes to improve early detection. Both the UKPDS and DCCT have clearly demonstrated that progression of retinopathy and nephropathy is linked to glycaemic control and that it is crucial that patients maintain HbA1c less than or equal to 6.5% to minimise disease progression. In contrast, the association between glycaemic/BP control and neuropathy progression is more tenuous.

Blood pressure

BP needs to be kept below 140/80 mmHg to prevent microvascular disease, but once this has been established it needs to be more aggressively treated with targets below 125/75 mmHg.

Angiotensin-converting enzyme inhibitors (ACEIs)

ACEIs and angiotensin receptor antagonists are first-line agents. Many clinical trials have demonstrated their efficacy in reducing proteinuria and delaying progression of renal failure. In the Heart Outcomes Prevention Evaluation (HOPE) study ramipril reduced overt nephropathy by 24%. In the Reduction of Endpoint in NIDDM with the Angiotensin II Antagonist Losartan (RENAAL) trial there was a 25% reduction in retinopathy progression and the risk of end-stage renal disease was reduced by 28%. Angiotensin blockade with ACEI also has a useful role in preventing retinopathy and reducing its progression by 50%. However, these agents are potentially teratogenic which needs to be considered when prescribing them to women of reproductive age.

Statins

Statins are useful in reducing the progression of nephropathy. They reduce proteinuria and have modest effects in
CME Diabetes

improving renal function. Patients with nephropathy need to have their low-density lipoprotein cholesterol levels brought below 2 mmol/L. Statins also have benefits in ameliorating retinopathy in animal models, though the evidence in clinical trials is less robust. The Fenofibrate Intervention and Event Lowering in Diabetes (FIELD) trial has shown some positive effects of fibrate therapy on retinopathy.

Screening

Microvascular disease needs to be identified early by robust screening methods. Nationwide screening for retinopathy started in the 1990s and has played a central role in reducing diabetes-related visual loss. Patients with significant nephropathy need to be referred according to national guidelines (Table 3). Nephropathy can be picked up early by testing for microalbuminuria, and neuropathy detected by detailed foot examination during annual review of the diabetic patient.

Conclusions

A combined approach of tight glycaemic control, aggressive BP control and cholesterol reduction will help reduce disease progression for both nephropathy and retinopathy, although neuropathy seems to be less affected. Patients with diabetes and their healthcare professionals need to be vigilant and detect microvascular disease at an early stage to avoid potentially devastating complications.

References


Table 3. Criteria for ophthalmology referral.

<table>
<thead>
<tr>
<th>Referral rate</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urgent (same day)</td>
<td>Sudden loss of vision, Ruberosis iridis, Pre-retinal/vitreous haemorrhage, Retinal detachment</td>
</tr>
<tr>
<td>Rapid</td>
<td>Proliferative retinopathy, Maculopathy (exudates/retinal thickening &lt; 1 disc diameter from fovea)</td>
</tr>
<tr>
<td>Routine</td>
<td>Any microaneurysm/haemorrhage &lt; 1 disc diameter from fovea associated with visual loss Pre-proliferative retinopathy with: venous beading, venous looping/reduplication, intraretinal microvascular abnormalities, multiple/deep blot haemorrhages</td>
</tr>
</tbody>
</table>
Insulin therapy and cancer risk in diabetes mellitus


Julia Platts, consultant in diabetes and medicine, University Hospital of Llandough, Cardiff

Type 2 diabetes (T2DM) is associated with a greater incidence of cancer, particularly of the pancreas, breast and colon. This association may be multifactorial, possibly linked to obesity, insulin resistance or hyperglycaemia. For example, carcinoma of the colon is associated with obesity, hyperglycaemia, metabolic syndrome, hypertriglyceridaemia, insulin treatment and raised insulin-like growth factor (IGF) levels.

Diabetes therapies

Metformin

Therapies used to treat patients with diabetes may increase or decrease their cancer risk. Population-based cohort studies support this, showing a higher cancer-related mortality in those treated with insulin or sulphonylureas compared with patients on metformin therapy. This may be due to a harmful effect of the sulphonylureas and insulin therapies or to a protective effect of metformin. Pilot studies from a diabetes database suggest the latter. The potential mechanism is that metformin activates adenosine monophosphate-activated protein kinase which may suppress tumour formation.

Insulin analogues

Intermittent exogenous insulin replacement is frequently unable to meet the challenging physiological demands in patients with diabetes, resulting in both hyperglycaemia and hypoglycaemia. The analogue insulins were developed with various modifications of human insulin by substitutions of amino acids and additions to delay or increase the rate of insulin absorption and to prolong or shorten activity (Fig 1). The analogues are divided into short- and long-acting compounds (Table 1). In England, insulin aspart is the most frequently prescribed short-acting insulin and insulin glargine the most frequently prescribed long-acting insulin (Fig 2). If these insulin increase mitogenicity, this may have a significant impact as most patients would be expected to remain on them for many years and have protracted exposure.