General Optical Council Approved CET For Optometrists
General Optical Council Approved CET For Dispensing Opticians

Macular oedema

Aetiology, differential diagnosis, and management

In the first of two articles looking at retinal eye disease, **Nathan Walker** and **Bishwanath Pal** look at macular oedema. Module C16600, one general CET point for optometrists and dispensing opticians

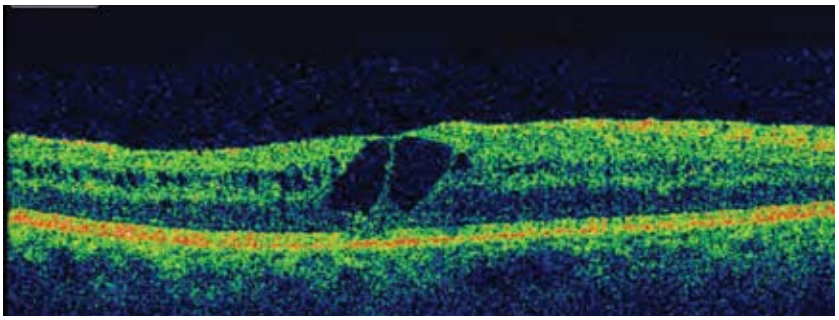

Figure 1 OCT scan showing fluid accumulation in the outer plexiform and inner nuclear layers with cyst formation at the fovea (cystoid macular oedema)

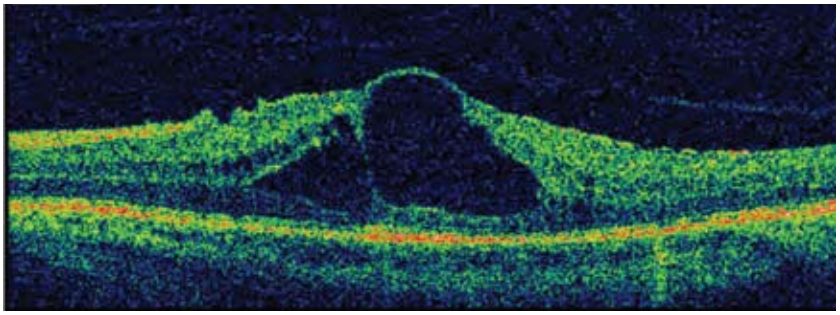

Figure 2 OCT scan showing large foveal cyst occupying nearly full thickness retina (cystoid macular oedema)

Macular oedema refers to the accumulation of fluid in retinal layers around the fovea, usually as a result of blood-retina barrier dysfunction. Macular oedema is not a specific entity, but rather a non-specific response to an abnormal retinal environment.

Vision is impaired due to disruption of the normal cellular relationships in the retina, mechanical stress, and a mild inflammatory response. The process begins with diffuse swelling of the outer retinal layers, and may advance to form the typical cyst-like spaces (termed 'cystoid macular oedema' – CMO) most often in the outer plexiform (Henle's) and inner nuclear layers (Figure 1). With increasing severity and duration, the cysts may enlarge, coalesce, and extend to involve all retinal layers from the retinal pigment epithelium to the internal limiting membrane (Figure 2). Uncommonly, the cysts may rupture, resulting in a type of macular hole.[1,2]

Causes

Macular oedema can occur in a wide variety of ocular conditions including diabetes, retinal vascular disease, age-related macular degeneration (AMD), uveitis, vitreoretinal traction, retinal dystrophies, and following intraocular surgery and trauma. It can be broadly classified by aetiology into inflammatory macular oedema and retinal vascular decompensation macular oedema, which influences the choice of treatment.[2]

Although the exact mechanism remains uncertain, it is thought that macular oedema most commonly results from dysfunction of the inner blood-retina barrier which is comprised of tight junctions between endothelial cells lining the retinal vessels. This barrier serves to restrict entry of plasma proteins and transudate from the vasculature to the neurosensory retina and maintain homeostasis. Meanwhile, tight junctions between retinal pigment epithelial cells form the outer blood-retina barrier which limits passage of fluid from the choroidal vessels to the neuroretina. Electrolytes and larger molecules undergo active transport. Inner or outer blood-retina barrier compromise leads to accumulation of fluid in the retina, with a predilection for cystic pooling at the fovea. Drainage of excess fluid from this region may be limited due to the absence of vasculature at the central macula, known as the 'foveal avascular zone'.[2,3]

Diabetes

Diabetes is the most common cause of blindness in the working age population in developed countries. It is estimated that around 8 per cent of the adult population has diabetes, with approximately half of these being undiagnosed. Landmark studies in the 1980-90s, the 'Diabetes Control and Complications Trial' (which looked at type 1 diabetics) and the 'United Kingdom Prospective Diabetes Study' (which examined type 2 diabetics), showed us that even with intensive blood sugar control, approximately three-quarters of these patients will develop some degree of diabetic retinopathy within 10 years of diagnosis. The risk of diabetic maculopathy increases with the duration of diabetes, affecting approximately 30 per cent of patients after 30 years of disease; 10 per cent develop vision threatening macular oedema. Interestingly, macular oedema can develop at any level of diabetic retinopathy.

Diabetes adversely affects blood vessels in several ways. The retinal capillaries undergo degenerative changes in the vessel wall (namely, loss of endothelial cells and pericytes) resulting in luminal narrowing, impaired perfusion, ischaemia, microaneursym formation, and transudation (leakage of fluid). These effects can be focal or diffuse. Generalised capillary incompetence leads to retinal swelling with a predilection for the macula.[2-5]

The 'Early Treatment Diabetic Retinopathy Study' defined clinically significant macular oedema ('CSMO') as: (a) retinal oedema within 500 microns of the fovea, (b) hard exudates within 500 microns of the fovea if associated with an area of retinal thickening, or (c) ▶

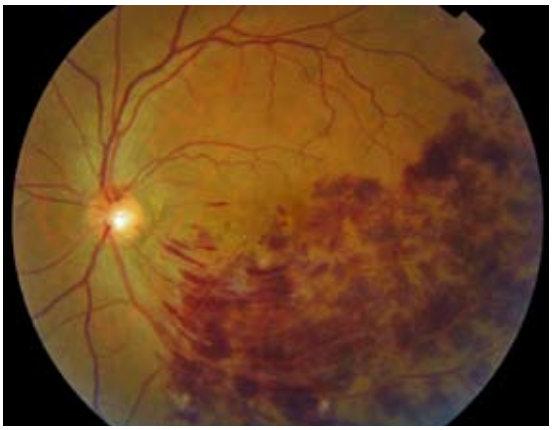

Figure 3a Colour fundus photograph of the left eye showing inferotemporal branch retinal vein occlusion with intraretinal haemorrhages, cotton-wool spots, and retinal oedema extending to the fovea

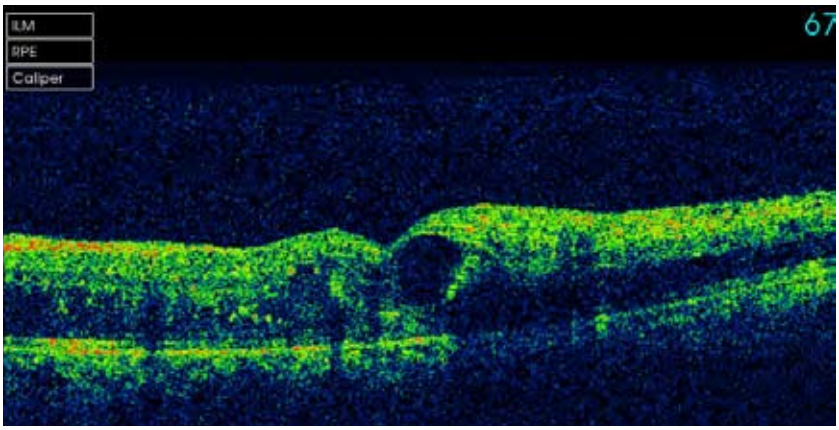

Figure 3b OCT from patient shown in Figure 3a, illustrating CMO and blockage of OCT signal due to retinal haemorrhage

TABLE 1
An aide-mémoire for CSMO

- Thickening within a FAZ
- HEx within a FAZ
- Disc within a disc

retinal oedema 1 disc area in size, any part of which is within 1 disc diameter of the fovea (Table 1). In that landmark study, macular laser treatment halved the rate of moderate visual loss (defined as doubling of the visual angle) in patients with CSMO from 25 per cent to 12 per cent, offering the first effective treatment for this condition.[6]

More recently, intravitreal injection of medications such as triamcinolone (a corticosteroid with relatively long-lasting anti-inflammatory properties) or the anti-vascular endothelial growth factor (anti-VEGF) agents – bevacizumab (Avastin) and ranibizumab (Lucentis) – have been shown to be effective in reducing macular oedema, but their effect is usually temporary. A recent study by the Diabetic Retinopathy Clinical Research Network ('DRCRnet') showed that intravitreal Lucentis has a significant beneficial complementary effect when combined with laser treatment for diabetic macular oedema and a low risk of adverse events (less than 1/1,000 risk of endophthalmitis per injection). Intravitreal triamcinolone was similarly effective in pseudophakic eyes, although there was a high rate of intraocular pressure rise with nearly 30 per cent needing pressure-lowering treatment.[7]

Vitrectomy currently has a limited role in the treatment of diabetic macular oedema, and is generally reserved for cases in which epiretinal or vitreous traction is thought to be contributing to the retinal thickening.[8]

As diabetes is a chronic, slowly progressive disease, long-term control of the oedema can prove challenging.

Radiation retinopathy can mimic diabetic retinopathy including the macular oedema. A history of radiotherapy to the eye or head will be present and the signs are usually unilateral.

Retinal vascular occlusion

Retinal vascular occlusive disease is the second most common cause of macular oedema after diabetic retinopathy. Obstruction of the retinal venous system causes vascular engorgement upstream from the sites of occlusion. This increases hydrostatic pressure on the inner blood-retina barrier which may also be impaired as a result of ischaemia, allowing fluid to leak from the retinal capillaries. The location and severity of venous occlusion determines the extent and severity of the resulting macular oedema such that central retinal vein occlusions carry a poorer prognosis than branch retinal vein occlusions.[2]

Branch retinal vein occlusion occurs in approximately one in 500 adults aged over 40, per year (Figures 3a, 3b). It is a major cause of visual loss as a result of macular oedema, retinal haemorrhages, and the consequences of retinal ischaemia (neovascularisation, vitreous haemorrhage, and tractional retinal detachment). The primary cause of the occlusion is typically compression of the vein at an arteriovenous crossing as a result of arteriosclerosis. Hence the risk factors are those of cardiovascular disease – advancing age, hypertension, diabetes, hypercholesterolaemia, obesity, and smoking. Blood clotting disorders and vasculitis are occasionally implicated, particularly in younger patients. The landmark Branch Vein Occlusion Study showed that macular laser treatment roughly doubled the likelihood of significant visual improvement from 37 per cent to 65 per cent when applied to patients with chronic macular oedema and reduced vision (6/12 or worse) in the absence of macular ischaemia. It has recently been shown that vision may continue to improve for at least 2-3 years in those treated with macular laser. Localised (sectoral) panretinal photocoagulation was suggested for neovascularisation.[9]

More recently, the BRAVO Study (2010) demonstrated the efficacy of monthly Lucentis injections for this condition. By month six, approximately 60 per cent of patients gained at least three lines of vision, compared to less than 30 per cent in the sham treatment group. This study is ongoing and long-term results are keenly awaited. In contrast, intravitreal steroid injections have been shown to be inferior to laser treatment for this condition (SCORE Study).[10]

Central retinal vein occlusions are approximately one-fifth as common as branch vein occlusions. Macular oedema, retinal haemorrhages, and ischaemia occur over a larger area and neovascular complications are much more common – hence the poorer visual prognosis. The Central Vein Occlusion Study showed macular laser treatment to be ineffective at improving vision in this condition. However, the recent CRUISE Study (2010) showed monthly intravitreal Lucentis is effective with nearly 50 per cent of patients gaining at least three lines of vision after six months of treatment, compared to only 17 per cent in the sham treatment group. These early reports are very encouraging, and ongoing research will elucidate optimal dosing schedules, cost-effectiveness, and the long-term effects of these new treatments.[11,12]

Age-related macular degeneration

Thirty per cent of the population aged over 75 has some degree of AMD. Ten to ▶

15 per cent of those have the 'wet' form (exudative AMD) which is characterised by choroidal neovascularisation (CNV), retinal pigment epithelial detachments, and their sequelae; while 85-90 per cent have the 'dry' form (atrophic AMD), characterised by intermediate or large drusen, retinal pigment epithelial changes, and slowly progressive chorioretinal atrophy. Macular oedema is a very important sign of CNV activity (Figure 4), as the new vessels have a tendency to leak (and bleed), causing visual loss as a result of subretinal and intraretinal oedema, haemorrhage, and scarring. While fundus fluorescein angiography (FFA) is typically required for definitive diagnosis of CNV, the presence of macular oedema on OCT is used to guide treatment with anti-vascular endothelial growth factor (anti-VEGF) medication (Avastin and Lucentis). Risk factors for AMD are advancing age (the strongest determinant of risk), family history, smoking (the most important modifiable risk factor), and other cardiovascular risk factors (hypertension, obesity etc). Ocular risk factors for exudative AMD are the presence of soft drusen, macular pigment changes, and the presence of CNV in the fellow eye. A poor diet (low in antioxidants and omega 3 fatty acids) and exposure to sunlight are suspected risk factors. Some genetic markers have been linked to AMD risk (eg complement factor H polymorphisms), but these are not yet clinically applicable.

Treatment has been revolutionised in recent years with the arrival of Lucentis. The MARINA and ANCHOR Studies showed that vision can be stabilised in around 95 per cent of patients and improved in around 35 per cent (Table 2). Monthly dosing is most efficacious but expensive and onerous for patients. Avastin has recently been shown to offer equivalent efficacy at a significantly lower cost, which will help improve access to treatment and reduce the financial burden placed on patients, governments, and insurers.[13]

Uveitis

Nearly half of all patients with uveitis have some degree of visual impairment from macular oedema, which is often the presenting complaint. Anti-inflammatory medication (corticosteroids) administered topically, systemically (orally), as a periocular depot injection, or intravitreally, are usually required.[2]

Postoperative

Between 1 and 5 per cent of patients who undergo cataract surgery develop CMO with peak incidence 6-10 weeks postoperatively. Most cases are subclinical and resolve spontaneously but may be observed on OCT or FFA. It is thought to result from sterile inflammation caused by release of inflammatory mediators from the iris, ciliary body, and retinal pigment epithelium. Risk factors include complicated or prolonged surgery with manipulation of the iris and/or vitreous loss, anterior chamber or sulcus placed intraocular lenses, diabetes, prostaglandin use, and history of CMO in the other eye. The release of inflammatory mediators causes inner blood-retinal barrier compromise leading to macular oedema. Other forms of ocular 'trauma' may cause macular oedema through similar mechanisms.[2]

As prostaglandins are thought to play a key role in the development of postoperative CMO, treatment involves non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids to inhibit prostaglandin synthesis. Topical NSAID eyedrops have better ocular penetration than oral NSAIDs, and Acular is the drug of choice.

For those patients who fail to improve on topical treatment, periocular or intravitreal steroid injections can be efficacious. Non-responders to this treatment may benefit from vitrectomy, although this is rarely needed.

Retinal dystrophies

Retinitis pigmentosa and other retinal dystrophies are associated with CMO which is thought to be secondary to increased permeability of the retinal pigment epithelium and perifoveal capillaries. Carbonic anhydrase inhibitors (eg oral acetazolamide, or topical dorzolamide or brinzolamide) can improve the oedema in some patients.[3]

Epiretinal membranes

Epiretinal membranes are thought to result from proliferation of metaplastic retinal glial cells. Contraction of these membranes can distort the retinal architecture, and macular oedema may develop due to mechanical traction on retinal capillaries. Vitrectomy surgery with epiretinal membrane peeling is offered when patients suffer reduced and/or distorted vision, and any associated macular oedema usually settles quickly once this traction is relieved.

Differential diagnosis

Thickening of the macula may also occur due to subretinal fluid accumulation which can be serous or rhegmatogenous in nature. The most common causes of serous macular detachment are choroidal neovascularisation (as discussed above) and central serous retinopathy (CSR) (Figure 5a, 5b). Other causes of exudative retinal detachment that may affect the macula include Coats' disease (peripheral retinal telangiectasia), malignant hypertension, Vogt-Koyanagi-Harada syndrome, posterior scleritis, benign or malignant choroidal tumours, and optic disc pit maculopathy. Residual subretinal fluid following retinal detachment repair is common in the first few weeks or even months after successful surgery; however, untreated peripheral retinal breaks should also be considered. X-linked juvenile retinoschisis may be confused clinically with macular oedema, but the young male patient (unusual for most of the other causes listed above), bilaterality of signs (although often asymmetric), characteristic picture on OCT, and accompanying peripheral retinoschisis are clues to this condition.

Full-thickness macular holes are often surrounded by a cuff of retinal oedema and subretinal fluid. If the hole is small it may be difficult to appreciate clinically, leading to confusion over the aetiology of the oedema. Older

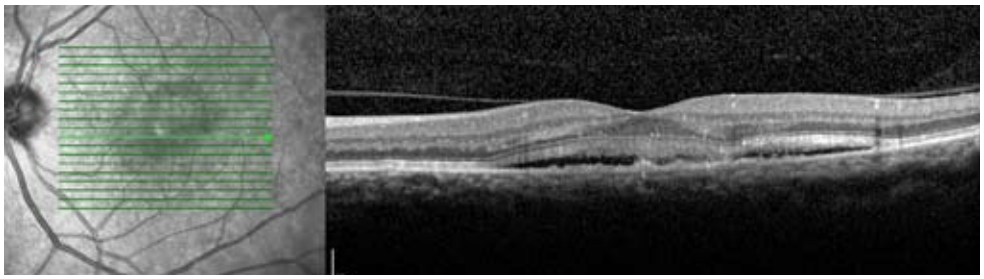

Figure 4 High resolution OCT showing subretinal fluid in active choroidal neovascular membrane. Intraretinal fluid is also frequently seen in this condition but not demonstrated here

TABLE 2

An aide-mémoire for ANCHOR and MARINA Study results, shown as Lucentis versus photodynamic therapy (for ANCHOR Study) or sham therapy (for MARINA Study) with rounded figures (see text; the figures are virtually the same for both studies)

Vision no worse 95% vs 65%
Vision improved 35% vs 5%
Average change +10 letters vs -10 letters

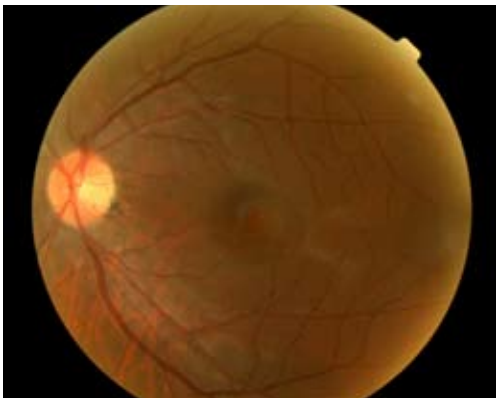

Figure 5a Colour fundus photograph of the left eye showing central retinal elevation and mild retinal pigment epithelial changes in central serous retinopathy

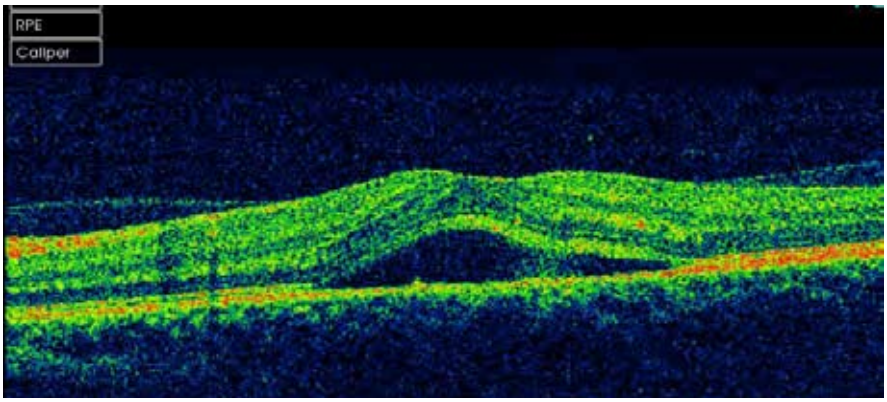

Figure 5b OCT showing subretinal fluid accumulation in central serous retinopathy

OCT machines would occasionally fail to illustrate the hole, as images were taken as a series of lines. This is much less of a problem with the modern, high-resolution instruments.

Clinical approach

Macular oedema typically presents with painless loss of vision in one eye, although it can be bilateral depending on the cause. Although the visual loss usually occurs gradually, patients may notice it suddenly when covering the fellow eye. As with any patient presentation, clinical evaluation begins with a thorough history. The age of the patient is important as it relates to the epidemiology of causative disorders, and the time-course of visual symptoms and severity of visual impairment are highly relevant as chronic severe cases are less likely to respond to treatment. A history of intraocular surgery (particularly recent cataract or vitreoretinal surgery), diabetic retinopathy, retinal vascular disease (eg retinal vein occlusion), inflammation (eg uveitis), injury, AMD, or retinal dystrophies should be sought; and general medical history of diabetes, cardiovascular disease, and radiotherapy considered. Drugs such as prostaglandins and nicotinic acid have also been implicated.

Depending on the amount of fluid present, dilated fundus examination may reveal loss of the normal foveal reflex and cystic changes at the macula.

Investigations

If the underlying cause is not obvious on history and ophthalmoscopy, ancillary testing with OCT and FFA may be necessary. OCT accurately determines retinal thickness and extent of oedema, affording highly valuable quantitative comparisons over time and is therefore especially useful in monitoring the response to treatment.[1,14]

Conclusion

Macular oedema can be caused by a wide variety of conditions. Careful history and examination, with the aid of targeted investigations, is usually diagnostic. Treatment depends on the underlying aetiology and may vary considerably from macular laser, anti-inflammatory medication, anti-VEGF injections, or a combination, and surgery is occasionally indicated. Chronic macular oedema causes retinal atrophy and gradual loss of vision, so timely referral to a retinal specialist is advisable.

Nathan Walker is an Australian ophthalmologist and vitreoretinal surgeon with fellowship training at Oxford Eye Hospital and Moorfields Eye Hospital, London. **Bishwanath Pal** is an ophthalmologist and medical retina consultant at Moorfields Eye Hospital

MULTIPLE-CHOICE QUESTIONS – take part at opticianonline.net

1 Which of the following is the commonest cause of macular oedema?
A Retinal vascular occlusion
B Diabetic eye disease
C Uveitis
D Trauma

2 What proportion of diabetics present with diabetic maculopathy?
A 10 per cent after 30 years
B 30 per cent after 10 years
C 30 per cent after 30 years
D 8 per cent

3 Macular oedema is associated with which of the following diabetic retinopathy levels?
A background
B Pre-proliferative
C Proliferative
D All the above

4 Which of the following statements about treatment of retinal vein occlusion is false?
A Macular laser treatment of patients with chronic macular oedema reduces acuity in the absence of maxcular ischaemia
B Monthly Lucentis injections may improve vision in patients with branch retinal vein occlusion
C Intravitreal steroid injections are superior to laser treatment for branch retinal vein occlusion patients
D Macular laser treatment is ineffective at improving vision in patients with central retinal vein occlusion

5 What percentage of patients with uveitis have some sight loss due to macular oedema?
A 1 per cent
B 5 per cent
C 10 per cent
D 50 per cent

6 Which of the following is diagnostic of clinically significant macular oedema (CSMO)?
A Hard exudates anywhere on the fundus
B Retinal oedema of 500 microns diameter within 1 disc diameter of the disc
C Retinal oedema 1 disc diameter in size within one disc diameter of the fovea
D Hard exudates within the FAZ without retinal thickening

Successful participation in this module counts as one credit towards the GOC CET scheme administered by Vantage and one towards the Association of Optometrists Ireland's scheme.
The deadline for responses is June 23 2011