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Spontaneous pneumothorax

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Pneumothorax describes the presence of gas within the pleural space, between the lung and the chest wall. It remains a globally important health problem, with considerable associated morbidity and healthcare costs. Without prompt management pneumothorax can, occasionally, be fatal. Current research may in the future lead to more patients receiving ambulatory outpatient management. This review explores the epidemiology and causes of pneumothorax and discusses diagnosis, evidence based management strategies, and possible future developments.

How common is pneumothorax?

Between 1991 and 1995 annual consultation rates for pneumothorax in England were reported as 24/100 000 for men and 9.8/100 000 for women, and admission rates were 16.7/100 000 and 5.8/100 000, respectively, in a study analysing three national databases.[1] The overall incidence represents a rate of one pneumothorax a year in an average sized general practice population. Across the United Kingdom this equates to around 8000 admissions for pneumothorax each year, accounting for 50 000 bed days given an average length of stay of just under one week.[2] These admissions alone have estimated costs of £13.65m for the National Health Service. Annual costs in the United States have been estimated at $130m.[3]

What are the types of pneumothorax?

Pneumothorax is categorised as primary spontaneous, secondary spontaneous, or traumatic (iatrogenic or otherwise). Traumatic pneumothorax is out of the remit of this review and will not be discussed.

The distinction between primary and secondary pneumothoraces is based on the absence or presence of clinically apparent lung disease. Primary and secondary pneumothoraces are distinct groups regarding morbidity and mortality, rates of hypoxia at presentation, and recommended management.[4] Although primary pneumothorax is not associated with known lung disease, most affected patients have unrecognised lung abnormalities that may predispose to pneumothorax. A small case-control study found that emphysema-like changes were identified on computed tomography in 81% of 27 non-smokers with primary pneumothorax compared with 0% in the control group of 10 healthy volunteers who did not smoke.[5]

SUMMARY POINTS

- Primary spontaneous pneumothorax is associated with smoking but defined as occurring in the absence of known lung disease
- Secondary spontaneous pneumothorax occurs in the presence of known lung disease and is associated with increased symptoms, morbidity, and rates of tension pneumothorax
- Immediate recognition and management of tension pneumothorax is required to prevent death
- Smoking increases the risk of pneumothorax and rates of recurrence, and smoking cessation is strongly advised
- Surgical intervention is warranted for patients with recurrent pneumothorax as the risk of further recurrence is high

Secondary pneumothorax is associated with considerably more morbidity and mortality than primary pneumothorax, in part resulting from the reduction in cardiopulmonary reserve in patients with pre-existing lung disease.

Tension pneumothorax is a life threatening complication that requires immediate recognition and urgent treatment. Tension pneumothorax is caused by the development of a valve-like leak in the visceral pleura, such that air escapes from the lung during inspiration but cannot re-enter the lung during expiration. This process leads to an increasing pressure of air within the pleural cavity and haemodynamic compromise because of impaired venous return and decreased cardiac output. Treatment is with high flow oxygen and emergency needle decompression with a cannula inserted in the second intercostal space in the midclavicular line. An intercostal drain is then inserted after decompression. Often emergency treatment must be based on a clinical diagnosis of tension pneumothorax before radiological confirmation, because of life threatening haemodynamic compromise. Radiographic features suggesting tension pneumothorax include cardiomediastinal shift away from the affected side and, in some cases, inversion of the hemidiaphragm and widening of intercostal spaces from the increased pressure within the affected hemithorax.

How is pneumothorax diagnosed?

Pneumothorax may be asymptomatic and diagnosed radiologically or may be suspected on the basis of typical clinical features. The most common symptoms are chest pain and breathlessness, characteristically with an acute onset, although these may be subtle or even absent. Patients with secondary pneumothorax tend to have more symptoms than those with primary pneumothorax as a result of coexistent lung disease. Clinical signs of pneumothorax include a reduction in lung expansion, a hyper-resonant percussion note, and diminished breath sounds on the affected side. The presence of hypotension and tachycardia may indicate tension pneumothorax.

In most patients the diagnosis will be confirmed on a standard, inspiratory chest radiograph. Routine expiratory films are not recommended routinely as they do not improve diagnostic yield, contrary to historical recommendations.[4] The hallmark of a pneumothorax on a radiograph is a white visceral pleural line separated from the parietal pleura and chest wall by a collection of gas, resulting in a loss of lung markings in this space (fig 1).

Features of pneumothorax may be more subtle on supine radiographs, with more air needed within the pneumothorax to confidently make a diagnosis. The deep sulcus sign, caused by air collecting in the costophrenic sulcus, apparently deepening it, may indicate pneumothorax on a supine radiograph.

Computed tomography provides sensitive and specific imaging for pneumothorax and is particularly useful for

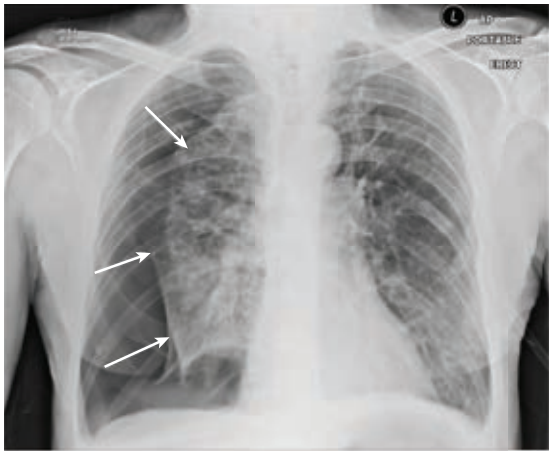

Fig 1 | Large right sided secondary pneumothorax in patient with severe chronic obstructive pulmonary disease and acute dyspnoea. White arrows indicate visceral pleura surrounding collapsed lung

complex disease processes, including pneumothoraces that are loculated as a result of areas of lung remaining adherent to parietal pleura, as well as facilitating radiologically guided drain insertion in difficult cases. Additionally, computed tomography is useful in distinguishing a pneumothorax from large bullae, which may occur in severe emphysema and can mimic the appearance of pneumothorax due to the absence of lung markings within a bulla. Typically, on chest radiographs bullae are indicated by a concave appearance, whereas a pneumothorax is suggested by a visceral pleural line running parallel to the chest wall; however, this distinction may be made clearly with computed tomography, potentially avoiding the serious complication of inserting a drain into lung parenchyma.

What predisposes to pneumothorax?

Primary spontaneous pneumothorax

The most important risk factor contributing to risk of primary pneumothorax is tobacco smoking. A retrospective study over 10 years conducted in Stockholm assessed the smoking habits of 138 patients with primary pneumothorax and compared their rates of smoking with a contemporary random sample of over 15 000 people from the same geographical area. Within this study, 88% of the patients with primary pneumothorax smoked. Compared with non-smokers the relative risk of a first pneumothorax is increased by ninefold in women who smoke and by 22-fold in men who smoke.[6] In addition this study found a striking dose-response relation between number of cigarettes smoked a day and risk of pneumothorax.[6] Cannabis smoking is associated with pneumothorax, an effect that may be attributed to both parenchymal damage from smoke and the longer breath-holds or valsalva manoeuvres that may be associated with smoking cannabis.[7]

The risk of primary pneumothorax is greater in tall men, which has led to the hypothesis that a greater alveolar stretch at the lung apex in tall men contributes to the increased risk.[8] Pneumothorax as a whole has a biphasic age distribution with primary pneumothorax peaking in those between the ages of 15 and 34 and secondary pneumothorax in those aged more than 55.[1]

Secondary spontaneous pneumothorax

Chronic obstructive pulmonary disease is the most common lung disease causing secondary pneumothorax, accounting for around 57% of cases.[9] The risk of pneumothorax seems to increase with worsening chronic obstructive pulmonary disease; around 30% of patients with secondary pneumothorax have a forced expiratory volume in one second of less than 1 litre.[10] Other causes of secondary pneumothorax include asthma, *Pneumocystis jirovecii* pneumonia related to HIV infection, cystic fibrosis, lung cancer, tuberculosis, interstitial lung disease, and endometriosis.

Thoracic endometriosis seems to have been an under-recognised cause of pneumothorax; a prospective study evaluating 32 women with pneumothorax referred for surgery found that 25% (n=8) had features suggesting pneumothorax associated with menses and seven of these women had histopathological confirmation of diaphragmatic endometriosis.[11] Specifically evaluating women for this possibility may significantly alter management.

What predicts recurrence of pneumothorax?

Primary spontaneous pneumothorax

Smoking cessation is the only proved modifiable risk factor for recurrence of primary pneumothorax. In a retrospective study of patients with primary pneumothorax, including 99 smokers, the absolute risk of recurrent pneumothorax in the four year follow-up period was 40% in those who stopped smoking compared with 70% in those who continued to smoke.[12] Recurrence of primary pneumothorax is also associated with increased height in men[12] and is significantly reduced by open surgery or video assisted thoracic surgery.[13]

Secondary spontaneous pneumothorax

Patients with pre-existing lung disease are more likely to experience a recurrent pneumothorax than those with primary pneumothorax.[14 15] In a retrospective study of 182 patients, of whom around half had chemical pleurodesis, recurrence rates at one year were 15.8% for primary pneumothorax and 31.2% for secondary pneumothorax.[15] Rates of recurrence of secondary pneumothorax are noticeably lowered by thoracic surgery: after video assisted thoracic surgery or axillary minithoracotomy, recurrence rates of around 3% were reported in a study with a mean follow-up period of 30 months,[13] whereas a separate study, with a similar duration of follow-up, reported recurrence rates of 43% in a control group of 86 patients with secondary pneumothorax.[10]

What is the goal of management?

The goal of acute treatment in pneumothorax is to exclude a tension pneumothorax and to relieve any dyspnoea. These goals are reflected by the different treatment algorithms in patients with primary or secondary pneumothorax, as patients with the latter are more likely to be symptomatic and more prone to associated cardiopulmonary compromise, in view of pre-existing disease. In contrast, patients with primary pneumothorax are often asymptomatic and tension pneumothorax is uncommon in this population.

Early studies evaluating treatment of pneumothorax focused on radiological resolution rather than patient centred outcomes, and this may have previously resulted in guidelines focused on intervention to remove air from the pleural space. Goals of treatment in pneumothorax are to exclude tension and reduce early morbidity and symptoms associated with pneumothorax, to limit inpatient

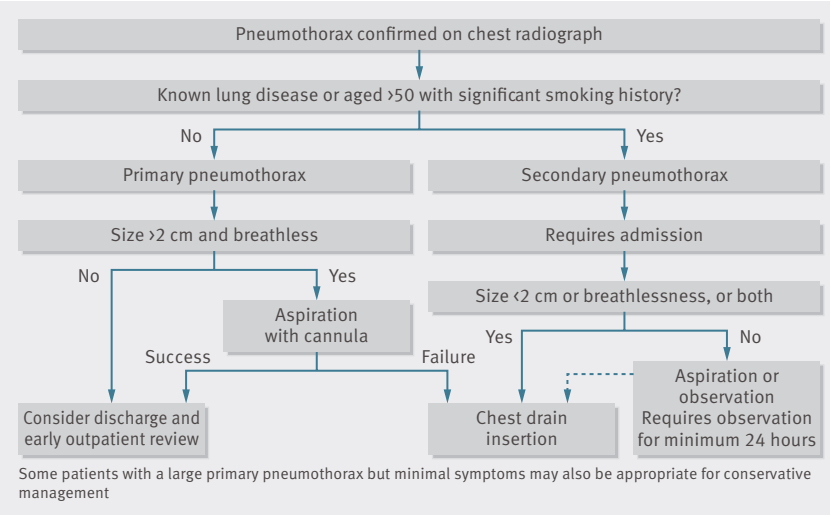

Fig 2 | Initial management of pneumothorax. Adapted from British Thoracic Society guidelines, MacDuff et al[4]

management where possible, to reduce the risk of recurrence, and to identify patients who would benefit from a definitive surgical procedure.

What are the treatment options?

Surprisingly for such a common condition there is considerable disparity in societal guidelines and worldwide practice for the management of pneumothorax. Management options range from observation through aspiration or drainage to thoracic surgical intervention. The choice is largely determined by symptoms and haemodynamic compromise, the size and cause of the pneumothorax, whether an episode is the first or recurrent, and the success or failure of initial management. Major differences exist between guidelines relating to the management of primary and secondary pneumothorax, some of which are outlined below.[3 4] One key difference between guidelines is the method of measuring pneumothorax: the British Thoracic Society defines a pneumothorax as large with a >2 cm measurement from the lung margin to chest wall at the level of the hilum, whereas the American College of Chest Physicians define this as ≥3 cm from the lung apex to the thoracic cupola. The measurement used within the British guidelines may have the advantage of identifying those pneumothoraces for which drain insertion in the "triangle of safety" is appropriate. Figure 2 summarises the current British Thoracic Society guidelines for the management of haemodynamically stable pneumothorax.

Primary spontaneous pneumothorax

Assuming that air leakage has stopped, a pneumothorax will gradually resolve as air is reabsorbed into pulmonary capillaries. The rate of resolution was calculated at 2.2% a day in a retrospective study assessing three dimensional estimates of pneumothorax size based on chest radiographs in patients treated conservatively.[16] The rate of reabsorption is increased fourfold when oxygen is administered[17] and therefore supplemental high flow oxygen is recommended when patients are admitted for observation.[4] A key difference between the American College of Chest Physicians Delphi consensus statement 2001[3] and the British Thoracic Society guidelines 2010[4] is the role of aspiration of air, as opposed to intercostal drain insertion. Whereas the British guidelines recommend aspiration for primary pneumothorax with a large (>2 cm) pneumothorax, the American consensus statement recommends inserting a chest drain or small bore catheter when intervention is required. Both the guidelines and consensus statement discourage the use of large bore "surgical" drains in uncomplicated pneumothorax in view of the similar success rate and lower levels of discomfort associated with smaller bore drains inserted with a seldinger technique (in which a guidewire is passed through a needle into the pleural space and a drain passed over the wire).[3 4]

A randomised controlled trial of 56 patients assessed manual aspiration against intercostal drain insertion in patients with large primary pneumothorax.[18] Success and recurrence rates did not differ between the groups and manual aspiration was associated with significantly shorter hospital stays, suggesting that this strategy is appropriate in this group. An earlier Cochrane review, limited by the inclusion of only a single randomised controlled trial, also suggested that aspiration was no different from chest drain insertion in terms of early success or success at one year, and was associated with a reduction in the number of patients admitted to hospital.[19]

Secondary spontaneous pneumothorax

Management of secondary pneumothorax tends to involve a more interventional approach because of the associated increased morbidity, symptoms, and cardiorespiratory compromise. In reflection of this, both American College of Chest Physicians and British Thoracic Society guidelines recommend admission for all episodes of secondary pneumothorax.[3 4] Oxygen is indicated, but some caution may be required for patients at risk of carbon dioxide retention. Although most patients may ultimately require an intercostal drain, the British guidelines recommend attempting aspiration for asymptomatic secondary pneumothorax measuring 1-2 cm at the hilum, whereas the American consensus statement suggests that this is not appropriate.[3 4]

Air leakage in secondary pneumothorax is less likely to settle spontaneously than in primary pneumothorax[20] and patients with secondary pneumothorax have a longer average length of stay than those with primary pneumothorax: more than 10 days in some series.[21] Discussion with a thoracic surgeon is advised after 48 hours of persistent air leakage, offering an individualised approach to surgical management dependent on risks of recurrence and surgical morbidity. Some patients are unfit for a definitive surgical procedure and may require a longer trial of conservative management or a less invasive management strategy.

Suction

The use of suction through chest drains has been employed in patients with persistent air leak or incomplete lung re-expansion in whom the rate of air leakage from the lung may be greater than the removal of air from the pleural space through the drain. This is utilised to increase the air flow out through the drain in the hope that if the visceral and parietal pleura can be apposed then the defect in the visceral pleura may heal more readily. A small randomised study of 23 patients found no significant differences in rates of lung re-expansion and duration of hospital stay between suction and no suction.[22] British Thoracic Society guidelines

TIPS FOR NON-SPECIALISTS

- Pneumothorax is associated with a sudden onset of breathlessness and pleuritic chest pain, although in some patients it can be asymptomatic
- The diagnosis can usually be made on chest radiographs, but computed tomography is sometimes required
- Management depends on whether the episode is a primary or secondary pneumothorax
- The presence of haemodynamic compromise with pneumothorax may indicate tension pneumothorax, which requires urgent decompression with a cannula through the second intercostal space in the midclavicular line
- Smoking cessation reduces the risk of recurrence of primary spontaneous pneumothorax
- After pneumothorax, air travel should be delayed until after definitive intervention or until resolution has been confirmed radiologically—the UK civil aviation authority recommends delaying air travel until two weeks after resolution

recommend that suction is not routinely employed in the management of pneumothorax but can be used if the lung fails to re-expand; a pressure of −10 to −20 cm H_2O as part of a high-volume low-pressure system is the recommended method.[4] Such a system should minimise the risk of increasing air leak and "air-stealing"—a process by which a large volume of each breath is entrained out of the chest through the drain. The early application of suction after drainage of a pneumothorax should be avoided because of an increased risk of re-expansion pulmonary oedema precipitated by the rapid reinflation of the collapsed lung.

Surgery

Axillary minithoracotomy and video assisted thoracic surgery are both used for the treatment of recurrent pneumothorax. A recent randomised controlled trial of 66 patients with primary or secondary pneumothorax allocated to minithoracotomy or to video assisted thoracic surgery showed equivalent recurrence rates (2.7% and 3%, respectively) and postoperative pain.[13] Compared with minithoracotomy, video assisted thoracic surgery was associated with higher patient satisfaction (assessed by use of the ipsilateral arm postoperatively) and return to activity, albeit at the expense of a longer procedure time.[13]

Pleurodesis

Pleurodesis is a procedure that precipitates an inflammatory process leading to the adherence of parietal and visceral pleura, thereby obliterating the pleural space. This can be achieved through instillation of an agent such as talc or tetracycline derivatives through a chest drain (medical pleurodesis) or by mechanical abrasion of the pleura or instillation of a suitable agent during an operation (surgical pleurodesis). Because of the inflammatory nature of pleurodesis, it can be painful and requires the application of local anaesthesia into the pleural space as well as adequate analgesia.

A randomised controlled trial of 214 patients with primary pneumothorax in Taiwan assessed the effect of minocycline pleurodesis on recurrence of pneumothorax at one year. All the patients had pigtail catheters for aspiration of their pneumothorax and were randomised to minocycline pleurodesis or to no pleurodesis. Recurrence rates were significantly lower (P=0.003) in the minocycline pleurodesis group (29.2%) compared with the control group (49.1%).[23] This method of treatment, however, typically necessitated a two day hospital stay, and the rate of recurrence in the control group was higher than that reported in other studies (33% at one year in one study[15]). An earlier smaller randomised study including participants with primary and secondary pneumothorax compared simple drainage with tetracycline or talc pleurodesis and found that the rate of recurrence over a mean follow-up period of 4.6 years was only 8% in the talc pleurodesis group but 36% in the simple drainage group.[24] British Thoracic Society guidelines suggest that chemical pleurodesis should be considered only in patients with an ongoing air leak who are not fit for surgical intervention, rather than as a primary treatment, in view of the significantly lower recurrence rates (around 3%) after surgery.[13]

What advice do patients need after a pneumothorax?

Given the considerable recurrence rate for pneumothorax it is important that patients are advised of the symptoms that may indicate recurrence and the need to seek medical advice if this occurs.

British Thoracic Society guidelines suggest that all patients with a pneumothorax are followed up by a respiratory physician around 2-4 weeks after the initial episode to ensure resolution and to identify and treat underlying lung disease.[4] Patients can be advised to return to work and normal activity after resolution of symptoms, although extreme exertion and contact sports should be delayed for longer and until full radiological resolution.[4]

Smoking cessation significantly reduces the recurrence rate in patients after an initial primary pneumothorax, with a relative risk reduction of over 40%.[12] Therefore patients should be made aware of this and provided with support to successfully stop smoking. Aside from medical intervention, smoking is the only modifiable risk factor predicting recurrence. Unfortunately, smoking cessation rates seem to be low after pneumothorax; more than 80% of patients in a retrospective study of 142 patients with primary pneumothorax continued to smoke one year after the episode.[25] For specific advice on diving and air travel see bmj.com.

What new treatments can be expected?

Conservative treatment

British Thoracic Society guidelines recommend that conservative management should be considered in patients with a small pneumothorax (<2 cm to lung edge at level of hilum) who are not breathless and acknowledge that it may be appropriate in patients with a large pneumothorax and minimal symptoms. An Australian randomised controlled trial is currently recruiting patients with larger primary pneumothorax to compare conservative management (observation then discharge if clinically stable) with standard management (aspiration and chest drain insertion if unsuccessful) on lung re-expansion at eight weeks as well as the effect on symptoms, complications, and recurrence.[27]

Quantification of air leak

Digital thoracic drainage systems allow a quantification of air leak that is not possible with a conventional underwater seal. These systems have been studied predominantly in patients with air leakage after thoracic surgery, but they may allow earlier stratification in pneumothorax, distinguishing those patients who are likely to have a persistent air leak from those whose air leak will settle with continued intercostal tube drainage.

Endobronchial valves

Endobronchial valves have been utilised as a non-surgical means of achieving a reduction in lung volume in emphysema and have also been studied as a treatment for persistent air leak in pneumothorax. These one-way valves may be inserted during a bronchoscopy, and when placed in segmental or subsegmental bronchi allow collapse of the distal lung and reduction in air leak while allowing drainage of secretions from distal airways. Endobronchial valves have been studied in 40 patients with varying causes of ongoing air leak, 25 of whom had spontaneous pneumothorax. Of the total, 93% (n=37) had a reduction or resolution in air leak, with 48% (n=19) achieving a complete resolution of leak.[28] This technique may allow a non-surgical method of managing patients who do not respond to conventional treatment, and prospective trials may help elucidate its role.

Blood patch

The effect of intrapleural injection of autologous blood was assessed in a small randomised controlled trial of 44 patients with advanced chronic obstructive pulmonary disease, secondary pneumothorax, and a persistent air leak after seven days of intercostal tube drainage.[29] This intervention was associated with a statistically significant reduction in ongoing air leak at 13 days. The air leak stopped in 9% (n=1) of those administered placebo and 73% (n=16) administered 1-2 mL/kg of blood, with greater success rates seen in those with a smaller air leak. Fourteen per cent of patients who were administered this dose of blood developed a low grade fever, which in all cases settled quickly with antibiotics. This study suggests that this technique may be useful as an alternative to chemical pleurodesis in patients with a significant risk from surgery.[29]

Ambulatory treatment

Heimlich valves are one-way flutter valves that may be attached to an intercostal drain in place of an underwater seal. They offer an outpatient treatment option for the management of pneumothorax, which may have an increasing role in the future. A randomised controlled trial of 48 patients with primary pneumothorax presenting to emergency departments compared Heimlich valves with needle aspiration and detected non-significantly lower rates of admission of 44% (n=11) in the valve group compared with 61% (n=14) in the needle aspiration group. At first outpatient review, full re-expansion of the lung occurred in 24% (n=6) of participants in the valve group compared with only 4% (n=1) in the needle aspiration group. Both procedures appeared safe, were well tolerated, and the intercostal drain was removed at a mean of 3.5 days in participants in the valve group.[30]

A subsequent systematic review (n=1235 cases) assessed available evidence for the use of Heimlich valves.[31] Despite being limited by a large proportion of unrandomised data with potential sources of bias, the review suggested an overall success rate of 85.8% with Heimlich valves, with successful treatment as an outpatient in 77.9% of cases. This treatment may offer benefits related to comfort and the avoidance of admissions with acceptable complication rates of 1.7%.[31] A larger well designed randomised controlled trial evaluating the use of Heimlich valves is required to evaluate the utility of this device.

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References are in the version on bmj.com.

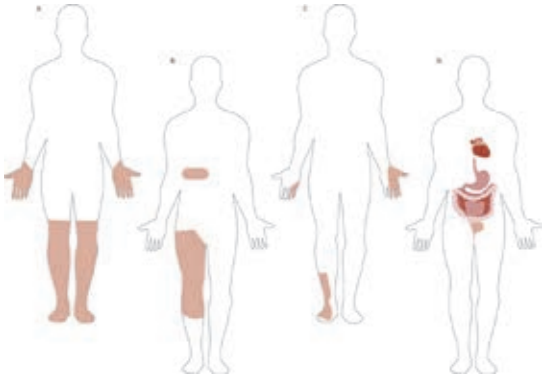
State of the Art reviews: Painful diabetic neuropathy

This week our State of the Art review is painful diabetic neuropathy (http://www.bmj.com/content/348/bmj.g1799). Diabetic sensorimotor polyneuropathy is the most common complication of diabetes and one third of people with it develop painful diabetic neuropathy.

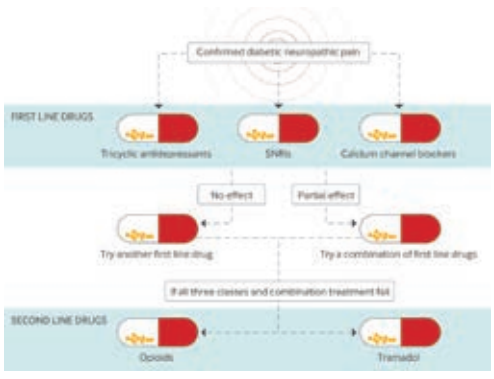
Painful diabetic neuropathy is more prevalent in type 2 diabetes than in type 1 disease and has a negative impact on physical and mental quality of life compared with painless diabetic neuropathy.

The review uses the latest evidence and guidelines to discuss the classification of painful diabetic neuropathy and its subtypes. The various diagnostic scores and surveys used to diagnose painful diabetic neuropathy in clinical and research settings are summarised.

Management of the underlying diabetes is the mainstay of preventing and delaying the progression of neuropathy. However, glucose control is more effective in decreasing the incidence of neuropathy in patients with type 1 diabetes than in those with type 2 disease. The evidence behind the three main categories of medication—antiepileptic medications, antidepressants affecting norepinephrine reuptake, and non-specific analgesics including opioids— is reviewed.



Patterns of nerve injury in patients with diabetic neuropathy



Algorithm for the treatment of diabetic neuropathy