Neuropathic pain: a practical guide for the clinician

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Abstract

Neuropathic pain, caused by various central and peripheral nerve disorders, is especially problematic because of its severity, chronicity and resistance to simple analgesics. The condition affects 2%–3% of the population, is costly to the health care system and is personally devastating to the people who experience it. The diagnosis of neuropathic pain is based primarily on history (e.g., underlying disorder and distinct pain qualities) and the findings on physical examination (e.g., pattern of sensory disturbance); however, several tests may sometimes be helpful. Important pathophysiologic mechanisms include sodium- and calcium-channel upregulation, spinal hyperexcitability, descending facilitation and aberrant sympathetic–somatic nervous system interactions. Treatments are generally palliative and include conservative non-pharmacologic therapies, drugs and more invasive interventions (e.g., spinal cord stimulation). Individualizing treatment requires consideration of the functional impact of the neuropathic pain (e.g., depression, disability) as well as ongoing evaluation, patient education, reassurance and specialty referral. We propose a primary care algorithm for treatments with the most favourable risk–benefit profile, including topical lidocaine, gabapentin, pregabalin, tricyclic antidepressants, mixed serotonin–norepinephrine reuptake inhibitors, tramadol and opioids. The field of neuropathic pain research and treatment is in the early stages of development, with many unmet goals. In coming years, several advances are expected in the basic and clinical sciences of neuropathic pain, which will provide new and improved therapies for patients who continue to experience this disabling condition.

Clinical presentation and patient evaluation

The blockade of nerve conduction in neuropathic conditions causes nerve dysfunction, which can result in numbness, weakness and loss of deep tendon reflexes in the affected nerve area. Neuropathic conditions also cause aberrant symptoms of spontaneous and stimulus-evoked pain. Spontaneous pain (continuous or intermittent) is commonly described as burning, shooting or shock-like. Stimulus-evoked pain includes allodynia (pain evoked by a nonpainful touch) and hyperalgesia (increased pain evoked by a painful stimulus). Allodynia can be caused by the lightest stimulation, such as skin contact with clothing or a light breeze. These sensory abnormalities may extend beyond nerve distributions (Fig. 1), which may lead to the inappropriate diagnosis of a functional or psychosomatic disorder. The diagnosis of neuropathic pain is based primarily on history and findings on physical examination.

Assessment of the patient with suspected neuropathic pain should focus on ruling out treatable conditions (e.g., spinal cord compression, neoplasm), confirming the diagnosis of neuropathic pain and identifying clinical features (e.g., insomnia, autonomic neuropathy) that might help individualize treatment. Box 1 lists principal details of the clinical evaluation, including history, physical examination and special tests.
Pathophysiology and molecular mechanisms of neuropathic pain

Table 1 highlights the clinical and pathophysiologic features of common neuropathic pain syndromes that are caused by nerve injury or dysfunction. Knowledge of the cellular and molecular mechanisms of neuropathic pain has advanced with the development of various experimental models of nerve injury. Both peripheral and central mechanisms (Fig. 2) have been proposed as being relevant to the pathogenesis of neuropathic pain.

Peripheral mechanisms

Regeneration after nerve injury results in the formation of neuromas and sprouting of new nerve projections among uninjured neighbouring neurons. Collateral sprouting then leads to altered sensory properties that may be realized as expanded receptive fields. Uncontrolled neuronal firing after experimental nerve injury is largely attributed to increased expression of sodium channels. This mechanism is supported by several lines of evidence, including blockade of neuropathic pain with sodium-channel-blocking local anesthetics. Demyelination of diseased nerves may be another cause of increased neuronal excitability.

In addition to sodium channels, expression of voltage-gated calcium channels is also increased following nerve injury. Calcium entry through voltage-gated calcium channels is necessary for the release of substance P as well as glutamate from injured peripheral nerves. Within the dorsal root ganglion, increased expression of the \( \alpha-2 \)-delta subunit of voltage-gated calcium channels correlates with onset and duration of allodynia. Clinical support of the role of this protein in neuropathic pain arises from the analgesic efficacy of \( \alpha-2 \)-delta voltage-gated calcium-channel antagonists, gabapentin and pregabalin.

Central mechanisms

Sustained painful stimuli result in spinal sensitization, which is defined as heightened sensitivity of spinal neurons, reduced activation thresholds and enhanced responsiveness to synaptic inputs (i.e., more likely to transmit pain to the brain). This can manifest in expansion of the affected area, increased response to painful inputs and transmission of pain following nonpainful stimuli. Central sensitization is largely mediated by the \( N \)-methyl-D-aspartate (NMDA) receptor. Although experimental NMDA-receptor blockade clearly suppresses central sensitization, analgesic efficacy of NMDA antagonists has been disappointing, likely because of the narrow therapeutic window of available agents.

Activation of descending pathways (the periaqueductal grey-rostral ventromedial medulla) has been shown to reduce pain transmission in animals and humans and is thought to contribute to the analgesic effect of opioids and antidepressants. Paradoxically, this system can also facilitate pain transmission and may contribute to some chronic pain states.

Sympathetically maintained pain

The importance of the sympathetic nervous system in neuropathic pain has been demonstrated by analgesia following sympathectomy in animals and humans, and by pain exacerbation through activation of the sympathetic nervous system. Sympathetically maintained pain may be explained by sprouting of sympathetic neurons into dorsal root ganglia of injured sensory neurons and postinjury sprouting of sympathetic fibres into the dermis.

Current management

Nonpharmacologic

Although many patients with neuropathic pain pursue complementary and alternative treatments, rigorous evidence supporting efficacy of nondrug therapy is limited. Some reports suggest benefits of conservative interventions such as exercise, transcutaneous electrical nerve stimulation, percutaneous electrical nerve stimulation, graded motor imagery and cognitive behavioural therapy or supportive psychotherapy.

Pharmacologic

One approach to estimate treatment efficacy using randomized controlled trial (RCT) data is based on the number-needed-to-treat (NNT) to obtain at least 50% pain relief in one patient. The NNT concept is hampered by methodologic variability across different RCTs, the short-term nature of most RCTs and the lack of consideration for other important outcomes (e.g., disability, quality of life). Also, most RCTs have involved patients with diabetic peripheral neuropathy and postherpetic neuralgia, and the results do not necessarily apply to all neuropathic pain conditions.
Antidepressants

Tricyclic antidepressants have repeatedly been shown to reduce neuropathic pain. Analgesic actions may be attributable to noradrenaline and serotonin reuptake blockade (presumably enhancing descending inhibition), NMDA-receptor antagonism and sodium-channel blockade. The NNT is about 3 both for balanced noradrenaline and serotonin reuptake inhibitors (e.g., amitriptyline) and predominantly noradrenaline reuptake inhibitors (e.g., nortriptyline).

Selective serotonin reuptake inhibitors (NNT = 6.7) and mixed serotonin–noradrenaline reuptake inhibitors (venlafaxine and duloxetine, NNT = 4.1–5.5) do not appear to be as effective as tricyclic antidepressants.

Anticonvulsants

Based on methodologically flawed trials, carbamazepine and phenytoin have NNTs of 2.1–2.3 for diabetic peripheral neuropathy. Both have significant adverse effects, making them generally poor candidates for first-line therapy. Carbamazepine, however, is still considered first-line therapy for trigeminal neuralgia, a unique neuropathic pain condition (NNT = 1.7). Oxcarbazepine, a newer anticonvulsant structurally related to carbamazepine, may also be useful; however, only one RCT (in diabetic peripheral neuropathy) has been published.

Gabapentin, an α-2-delta subunit voltage-gated calcium-channel antagonist, has repeatedly demonstrated analgesic

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**Box 1: Clinical evaluation of patients with suspected neuropathic pain**

**History**

*Pain intensity*
- 0–10 rating scale (0 = no pain, 10 = worst pain imaginable)
- Rate pain at initial presentation and at subsequent visits to track treatment response

*Sensory descriptors*[^25][^21][^26]
- Pain qualities: hot, burning, sharp, stabbing, cold, allodynia (pain brought on by light touch, clothing or bed sheets)
- Common nonpainful sensations: tingling, prickling, itching, numbing and “pins and needles”

**Temporal variation**
- Neuropathic pain often gets worse towards the end of the day
- Neoplastic process should be suspected if pain has been progressively increasing over recent months

**Functional impact**
- Effect of pain on sleep, ambulation, self-care, activities of daily living, work, social or sexual function, mood and suicidal ideation[^31]

**Attempted treatments**
- Neuropathic pain is generally resistant to acetaminophen and NSAIDs
- Determine and document adequacy of dose titration for titratable drugs (e.g., dose reached and duration of treatment, drug treatment stopped owing to adverse effects or lack of efficacy)[^12]

**Alcohol or substance abuse**
- Addiction history will affect decision to prescribe opioids or cannabinoids
- Consider earlier involvement with a psychologist or psychiatrist[^33]
- Consider safety of sedative analgesics with alcohol or other sedatives

**Physical examination**

**Gross motor examination**
- Motor weakness may occur around the involved nerves
- Attempt to differentiate between true weakness and antalgic weakness

**Deep tendon reflexes**
- May be diminished or absent around the involved nerves

**Sensory examination**
- Light touch, pin prick, vibration sense and proprioception may be diminished or absent in the involved nerve territory
- Sensory disturbance may aberrantly extend beyond a discrete nerve territory
- Dynamic allodynia (pain due to cotton wool lightly moving across the skin)
- Thermal allodynia (burning sensation in response to ice cube on skin)
- Pinprick hyperalgesia (exaggerated pain following pinprick to the skin)
- Pain when straight leg is raised, suggestive of irritation of lumbar nerve root
- Elicitation of myofascial trigger points to favour a diagnosis of myofascial pain over neuropathic pain
- Possible presence of Tinel’s sign (distally radiating paresthesias upon percussion of damaged or regenerating nerve fibres)

**Skin examination**
- Alterations in temperature, colour, sweating and hair growth suggestive of complex regional pain syndrome[^34]
- Residual dermatomal scars consistent with previous herpes zoster (shingles) infection
- Characteristic skin changes consistent with diabetes mellitus

**Special tests**

**CT and MRI scans**
- Facilitate specific diagnosis (e.g., herniated disc, nerve infiltration by tumour)

**Electromyography and nerve conduction studies**
- May provide objective evidence of nerve injury or dysfunction[^15]
- Nerve conduction studies evaluate large fibre function; therefore, small fibre neuropathy cannot be ruled out if results of nerve conduction studies are normal

**Three-phase nuclear medicine bone scan**
- May help diagnose complex regional pain syndrome[^36]

**Clinical biochemistry**
- Conduct tests to help identify cause of neuropathy; for example, glucose tolerance testing, thyroid function, measurement of vitamin B₁₂ levels, CD4+ T-lymphocyte count
efficacy and improvements in mood and sleep in several RCTs (NNT = 3.8). Pregabalin is a gabapentin analogue with a similar mechanism, higher calcium-channel affinity and better bioavailability. Pregabalin was superior to placebo in several RCTs in diabetic peripheral neuropathy and postherpetic neuralgia (NNT = 4.2).

RCTs of other anticonvulsants, including valproate, lamotrigine and topiramate, have had equivocal results.

Opioid analgesics

The role of opioid analgesics in neuropathic pain has been controversial. However, a recent meta-analysis provides convincing evidence of benefit. Although 14 short-term RCTs (< 24 hours) showed contradictory results, 8 intermediate-term RCTs (≤ 8 weeks) demonstrated important efficacy. These RCTs demonstrated, on average, a 20%-30% pain reduction. For morphine and oxycodone, the NNT ranged from 2.5 to 2.6. However, beneficial effects on mood, quality of life and disability are not consistent. There were no reports of addiction or abuse in these RCTs, although the risk is likely to be low given the common exclusion criterion of substance abuse history. Currently, there is a dearth of evidence supporting the long-term efficacy of opioids in controlling neuropathic pain. However, the results of a recent retrospective review involving more than 100 patients (most of whom had neuropathic pain) who had received chronic opioid therapy for 1 year or more suggest that many patients may continue to enjoy persistent pain relief with opioids.

Tramadol is a weak opioid and a mixed serotonin-noradrenaline reuptake inhibitor. Three RCTs of tramadol for neuropathic pain have yielded an overall NNT of 3.9. Methadone is a synthetic opioid potentially useful for controlling neuropathic pain because of its NMDA-antagonist properties. However, its long half-life (24–36 hours) necessitates extremely careful dose titration. Two small RCTs of methadone demonstrated benefit in managing neuropathic pain, and open-label experience suggests promise in a wide variety of neuropathic pain conditions.

NMDA antagonists

Because of the critical role of NMDA activity in central sensitization, NMDA antagonists hold promise in the management of neuropathic pain. Unfortunately, available agents have limited efficacy and produce intolerable side effects. Ketamine, an intravenous anesthetic with NMDA-antagonist activity, has been found to be effective in small RCTs; however,

Table 1: Clinical features and pathophysiology of common neuropathic pain syndromes

<table>
<thead>
<tr>
<th>Diagnosis (inciting cause)</th>
<th>Typical clinical features</th>
<th>Putative pathophysiology and clinical pathogenesis</th>
</tr>
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<tbody>
<tr>
<td>Painful diabetic neuropathy (hyperglycemia)</td>
<td>Symmetrical sensory loss and burning pain in lower legs</td>
<td>Hyperglycaemia, hyperlipidaemia, hypoinsulinemia, growth factor deficiency → oxidative stress and autoimmunity → progressive demyelination and axonal loss → sensory loss, paresthesia, dysesthesias, pain and allodynia</td>
</tr>
<tr>
<td>Lumbosacral radiculopathy (herniated intervertebral disc)</td>
<td>Lancinating pain radiating into the anterior thigh (L2/3) or lower leg (L4-5) with motor weakness or sensory loss</td>
<td>Spinal nerve root compression, inflammatory effects of extruded nucleus pulposus, sensory and motor abnormalities, radiating pain</td>
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<tr>
<td>Postherpetic neuralgia (varicella zoster virus infection)</td>
<td>Unilateral pain, sensory loss or allodynia in the dermatome where herpes zoster had previously erupted</td>
<td>Dorsal horn atrophy, sensory ganglion (primary afferent neuron) cell, axon and myelin loss and fibrosis, sensitization of unmyelinated cutaneous nociceptors (“irritable nociceptors”) and/or small fibre deafferentation and allodynia and/or small and large fibre deafferentation, sensory loss, pain and allodynia</td>
</tr>
<tr>
<td>HIV-related neuropathy (HIV infection)</td>
<td>Symmetrical painful paraesthesias, most prominent in the toes and soles of the feet</td>
<td>Direct viral invasion of sensory neurons? HIV-mediated macrophage infiltration of peripheral nerves? Neurotoxicity of reverse transcriptase inhibitors Sensory loss, pain and allodynia</td>
</tr>
<tr>
<td>Complex regional pain syndrome</td>
<td>Regional (e.g., limb) pain together with edema, cutaneous blood flow and sweating abnormalities</td>
<td>“Coupling” of sympathetic neurons with injured sensory neurons at peripheral neurona sites or dorsal root ganglion sites of injured afferent nerves → development of noradrenergic sensitivity following nerve injury Pain, allodynia, hyperalgesia, edema, cutaneous blood flow and sweating abnormalities</td>
</tr>
<tr>
<td>Postsurgical neuropathic pain (surgical procedure)</td>
<td>Peri-incisional sensory loss, pain and allodynia for more than 3 months after surgery; phantom pain following amputation or mastectomy</td>
<td>Phantom pain in 30%-81% of amputations, thoracotomy pain in 11%-57%, postherniorrhaphy in 37% or less, postmastectomy pain in 66%-83%, poststernotomy in 54% or less</td>
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</tbody>
</table>
Psychomimetic side effects are dose limiting. Dextromethorphan, a common cough suppressant and NMDA antagonist, has produced uncertain results in controlling neuropathic pain, showing modest benefit in diabetic peripheral neuropathy, but not in postherpetic neuralgia.

Topical agents

Locally acting analgesics are attractive because they may cause minimal systemic side effects. The lidocaine patch 5% has been shown to relieve localized pain in postherpetic neuralgia with no increase in side effects (NNT = 4.4). Although the lidocaine patch 5% is not available in Canada, pharmacists can make up the gel or cream at a concentration of 5%–10%. Capsaicin, an ingredient of hot peppers, has shown mixed results in RCTs, and some patients with postherpetic neuralgia have reported pain exacerbation. One RCT evaluating topical doxepin, capsaicin and their combination demonstrated significant analgesia with all 3 of these interventions.

Miscellaneous drugs

Mexiletine, an oral antiarrhythmic agent and sodium-channel blocker, was superior to placebo in only 2 of 7 RCTs. Clonidine, an α2-agonist sympathetic blocker, was shown to be effective in a subset of patients with diabetic peripheral neuropathy. Cannabinoids have been found to play a role in ex-
perimental pain modulation, and there is growing evidence of their efficacy in managing neuropathic pain. The cannabinoid dronabinol provided modest analgesic benefit in an RCT of central pain in multiple sclerosis. An oromucosal spray containing a mixture of tetrahydrocannabinol and cannabidiol provided modest benefit in another RCT of central pain in multiple sclerosis and in an RCT of neuropathic pain following brachial plexus avulsion.

Comparative trials

Given the limitations of comparing treatments across trials using NNTs, several investigators have compared treatments within single trials. For example, 3 comparative RCTs suggest that analgesia with desipramine or nortriptyline is comparable to that of amitriptyline but with fewer side effects. Other studies suggest that opioids may be more efficacious than tricyclic antidepressants or gabapentin and that gabapentin is comparable to amitriptyline and venlafaxine analgesia is comparable to that of imipramine. These are, however, early impressions from small RCTs. Larger RCTs that incorporate head-to-head comparisons are needed.

Combination pharmacotherapy

Given the limited effectiveness of current treatments, combining different drugs may result in improved results at lower doses and with fewer side effects. Many patients with neuropathic pain currently receive drug combinations, albeit in the absence of supportive evidence. In a recent RCT, analgesia with a morphine–gabapentin combination was superior to treatment with either drug alone. In a study involving 11 patients who did not respond to gabapentin, a gabapentin–venlafaxine combination was superior to gabapentin alone. In another RCT, the addition of the neuroleptic fluphenazine to amitriptyline therapy provided no benefit. Future trials are needed to evaluate optimal drug combinations and dose ratios as well as safety, compliance and cost-effectiveness.

Trigeminal neuralgia and other paroxysmal pain

Trigeminal neuralgia and glossopharyngeal neuralgia (idiopathic or related to multiple sclerosis) are unique conditions. They are characterized by orofacial, paroxysmal, shock-like pains triggered by light, localized, tactile stimulation with minimal constant pain between paroxysms. These syndromes are also distinguished by their high responsiveness to carbamazepine. Baclofen is a muscle relaxant shown to be useful in trigeminal neuralgia in the setting of resistance to carbamazepine. High success rates have also been reported following invasive treatments such as microvascular decompression, trigeminal ganglion balloon compression and stereotactic (gamma knife) radiosurgery.

Interventional pain management

Although rigorous supportive evidence is limited, more invasive treatments may be considered for patients with intractable neuropathic pain. Procedures include epidural or perineural injections of local anesthetics or corticosteroids, implantation of epidural and intrathecal drug delivery systems, neural ablative procedures (e.g., Gasserian ganglion glycerol injection or gamma knife surgery) and insertion of spinal cord stimulators, just to name a few. Consideration of highly invasive procedures such as insertion of intrathecal infusion pumps or spinal cord stimulators is generally reserved for patients with no surgically treatable pathology who have failed more conservative treatments and undergone psychological evaluation. Although this level of caution may also be applied to nerve block procedures, some conditions could warrant nerve blocks earlier in the clinical course. For example, sympathetic nerve blocks in early complex regional pain syndrome may be a crucial adjunct for the facilitation of physiotherapy and rehabilitation.

Approach to neuropathic pain management in primary care

No single drug works for all neuropathic pain states, and given the diversity of pain mechanisms, patient responses and diseases, treatment must be individualized. Other than analgesia, factors to consider when individualizing therapy include tolerability, other benefits (e.g., improved sleep, mood and quality of life), low likelihood of serious adverse events and cost-effectiveness to the patient and the health care system. The evidence-based approach presented here may require revision as newer treatments and clinical evidence become available.

Pain management requires ongoing evaluation, patient education and reassurance. Diagnostic evaluation of treatable underlying conditions (e.g., spinal cord compression, herniated disc, neoplasm) should continue concurrently with pain management. Patients require education regarding the natural history of their condition and realistic treatment expectations (e.g., current treatments are not curative and analgesia is rarely complete). Even a 30% pain reduction is clinically important to patients. Pain severity, patient complexity (e.g., coexisting depression or substance abuse), failure of attempted treatments and availability of health care resources should be considered when planning referrals to pain clinics and related specialists. Patient compliance and adequacy of analgesic drug titrations (e.g., dose and duration of treatment) should be continually evaluated and documented.

Neuropathic pain is best managed with a multidisciplinary approach. Nevertheless, several different treatments can be initiated in the primary care setting (Fig. 3). Treatments with the lowest risk of adverse effects should be tried first. Evidence supporting conservative nonpharmacologic treatments (e.g., physiotherapy, exercise, transcutaneous electrical nerve stimulation) is limited; however, given their presumed safety, nonpharmacologic treatments should be considered whenever appropriate. Simple analgesics (e.g., acetaminophen, NSAIDs) are usually ineffective in pure neuropathic pain but may help with a coexisting nociceptive condition (e.g., sciatica with musculoskeletal low-back pain). Early referrals to a
pain clinic for nerve blocks may be warranted in some cases to facilitate physiotherapy and pain rehabilitation.

Topical treatment with lidocaine, indicated for postherpetic neuralgia and focal neuropathy, could be tried first if it is available at a cost reasonable to the patient. For other neuropathic pain diagnoses or lidocaine treatment failures, we recommend initiating oral monotherapy with gabapentin or pregabalin, a tricyclic antidepressant, or a mixed serotonin-norepinephrine reuptake inhibitor. Of these treatments, gabapentin or pregabalin appear to be the best tolerated, with very few drug interactions. Tricyclic antidepressants appear to be more efficacious and much less expensive but have a higher likelihood of adverse effects and are relatively contraindicated for use in patients with serious cardiovascular disease (a screening electrocardiogram is recommended before prescribing tricyclic antidepressants), postural hypotension, urinary retention and angle-closure glaucoma. Among available tricyclic antidepressants, nortriptyline and desipramine are more highly recommended because of fewer side effects. Newer mixed serotonin-norepinephrine reuptake inhibitors (e.g., venlafaxine, duloxetine) may not be as efficacious as tricyclic antidepressants but appear to be better tolerated.

Little is known about whether the response to one drug predicts the response to another. However, if the first oral medication tried is ineffective or not tolerated, one might switch to alternate monotherapy. In the event that all of the first-line oral monotherapies tried are ineffective or poorly tolerated, we would then recommend initiating monotherapy with tramadol or an opioid analgesic. Long-term prescribing of opioid analgesics requires special prescribing and regulatory considerations.126–129 In Canada, where tramadol is available only as a fixed-dose combination with acetaminophen, the upper dose limit of tramadol will be dic-

![Fig. 3: Algorithm for the management of neuropathic pain in primary care.](image-url)
Table 2: Neuropathic pain medications*

<table>
<thead>
<tr>
<th>Drug</th>
<th>Drug interactions</th>
<th>Adverse effects</th>
<th>Dosage</th>
<th>Usual effective dose (and maximum)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topical</strong></td>
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<tr>
<td><strong>Lidocaine 5%</strong></td>
<td>Possible systemic absorption in patients taking oral therapy with class 1 antihypertensive drugs</td>
<td>Skin erythema, rash</td>
<td>1-3 patches every 12 h</td>
<td>3 patches every 12 h</td>
<td>Patch must be applied to painful area</td>
</tr>
<tr>
<td><strong>Tricyclic antidepressants (amitriptyline, imipramine, nortriptyline, desipramine)</strong></td>
<td>Metabolism by CYP450 2D6 (note: rapid v. slow metabolizers), potentiates other sedatives</td>
<td>Cardiac conduction block, orthostatic hypotension, sedation, confusion, urinary retention, dry mouth, constipation, weight gain</td>
<td>10-25 mg/d, at bedtime or in divided doses every 12 h; increase dose weekly by 10-25 mg/d</td>
<td>50-150 mg/d; median 50-75 mg/d</td>
<td>More adverse events with amitriptyline and imipramine; contraindicated in patients with glaucoma and those taking MAOIs</td>
</tr>
<tr>
<td><strong>SNRIs</strong></td>
<td>Metabolism by CYP450 2D6</td>
<td>Sedation, ataxia, nausea, dry mouth, constipation, hyperhidrosis, anorexia</td>
<td>60 mg once daily; 60 mg every 12 h also safe and effective</td>
<td>60 mg/d (maximum 120 mg/d)</td>
<td>Contraindicated in patients with glaucoma and those taking MAOIs; recent US FDA approval for use in diabetic neuropathy</td>
</tr>
<tr>
<td><strong>Venlafaxine</strong></td>
<td>Metabolism by CYP450 2D6 and 3A4</td>
<td>Hypertension, ataxia, sedation, insomnia, nausea, hyperhidrosis, dry mouth, constipation, anxiety, anorexia</td>
<td>37.5 mg once daily; increase dose weekly by 37.5 mg/d</td>
<td>150-225 mg/d (maximum 375 mg/d)</td>
<td>Dose adjustment in patients with renal dysfunction; contraindicated in patients taking MAOIs</td>
</tr>
<tr>
<td><strong>Anticonvulsants</strong></td>
<td>Metabolism by CYP450 3A4, 1A2 and 2C8; inducer of CYP450 1A2, 2C and 3A</td>
<td>Sedation, ataxia, diplopia, hyponatremia, agranulocytosis, nausea, diarrhea, hepatotoxicity, aplastic anemia, Stevens-Johnson syndrome</td>
<td>100-200 mg/d, in divided doses every 6-8 h; increase dose weekly by 100-200 mg/d</td>
<td>600-1200 mg/d (maximum 1600 mg/d); for trigeminal neuralgia, controlled-release CBZ every 8-12 h, with short-acting CBZ every 4 h for rescue</td>
<td>First-line therapy for trigeminal neuralgia only; contraindicated in patients with porphyria or atrioventricular block and in those taking MAOIs; monitor CBC, liver function test results and blood levels</td>
</tr>
<tr>
<td><strong>Carbamazepine (CBZ)</strong></td>
<td>Simple antacids reduce bioavailability</td>
<td>Sedation, ataxia, edema, weight gain, diplopia, nystagmus</td>
<td>300-900 mg/d, in divided doses every 8 h; increase dose weekly by 300 mg/d</td>
<td>1200-2400 mg/d (maximum 3600 mg/d)</td>
<td>Dose adjustment in patients with renal dysfunction</td>
</tr>
<tr>
<td><strong>Gabapentin</strong></td>
<td>None documented to date</td>
<td>Sedation, ataxia, edema, diplopia, weight gain, dry mouth</td>
<td>50-150 mg/d, in divided doses every 8-12 h; increase dose weekly by 50-150 mg/d</td>
<td>300-600 mg/d (maximum 600 mg/d)</td>
<td>Dose adjustment in patients with renal dysfunction</td>
</tr>
<tr>
<td><strong>Opioids</strong></td>
<td>Metabolism by CYP450 2D4; risk of serotonin syndrome with SSRI co-administration</td>
<td>Respiratory depression, ataxia, sedation, constipation, seizures, nausea, orthostatic hypotension</td>
<td>50 mg/d, in divided doses every 12 h; increase dose weekly by 50 mg/d</td>
<td>200-400 mg/d (maximum 800 mg/d)</td>
<td>Use with caution in patients with epilepsy</td>
</tr>
<tr>
<td><strong>Tramadol</strong></td>
<td>Potentiates other sedatives</td>
<td>Respiratory depression, sedation, nausea, constipation, cognitive dysfunction</td>
<td>5-15 mg (short-acting) every 4 h as needed; after 1-2 wk convert to long-acting preparation and continue dose titration as needed</td>
<td>Benefits of daily morphine equivalents &gt; 180 mg/d have not been established</td>
<td>Screen patients for alcohol/substance abuse and consider “opioid contract”; co-administer pre-emptive stool softeners and antiemetics</td>
</tr>
</tbody>
</table>

Note: CYP450 = cytochrome P450 enzyme, MAOI = monoamine oxidase inhibitor, SNRI = mixed serotonin-norepinephrine reuptake inhibitor, FDA = Food and Drug Administration, CBC = complete blood count, SSRI = selective serotonin reuptake inhibitor.

*This is a nonexhaustive list that includes medications recommended in Fig. 3.
tated by the risk of acetaminophen-related hepatotoxicity (i.e., <4000 mg acetaminophen).

Although supportive evidence is limited, polypharmacy may be helpful. Therefore, in the event of a partial response to any single drug, one could add an alternate drug. If none of the above tried treatments is effective or tolerated, referral to a pain clinic is warranted for consideration of third-line drugs, interventional treatments and pain rehabilitation programs.

Prescribing considerations

Table 2 provides basic information on drugs recommended in Fig. 3. Given the potential for drug interactions,20 a thorough review of the patient’s current medications is warranted before prescribing any drugs for neuropathic pain. Given the potential for overdose toxicity with opioids and tricyclic antidepressants, suicide risk should be evaluated before prescribing. Some patients need reassurance that analgesia with antidepressants and anticonvulsants does not necessarily imply a diagnosis of depression or epilepsy. Because the central nervous system is depressed by most tricyclic antidepressants, anticonvulsants and opioids, gradual drug dose titration over weeks, toward a maximal tolerated dose, allows for accommodation to adverse effects while reaching an effective dose. Because of this need for gradual dose titration, the physician and patient need to recognize that onset of pain relief will be gradual. If possible, nursing resources should be devoted to weekly patient contact to guide dose titration. Since tricyclic antidepressants are rapidly metabolized in some patients, plasma tricyclic antidepressant levels should be measured if no analgesic or adverse effects are observed at maximal doses so as to safely guide further dose increases.15 In elderly people, drug treatment should be started at the lowest possible dose and be increased very slowly (i.e., longer titration period) to minimize the risk of falling and related trauma.

Conclusion

Neuropathic pain is a devastating chronic condition that generally can be diagnosed by history and findings on physical examination. For some neuropathic pain syndromes, available treatments are tolerable and afford meaningful relief to a considerable proportion of patients. Nevertheless, many patients report intractable and severe pain, and better treatment strategies are desperately needed.12 The field of neuropathic pain research and treatment is in the early stages of development, with many goals yet to be achieved. In particular, future laboratory, clinical and epidemiologic research into pathogenesis,64-136 treatment2,18,118,137,138 and prevention133-135 of neuropathic pain is expected as well as improved dissemination of new information to health professionals and the public. Over the years to come, many upcoming advances are expected in the basic and clinical science of neuropathic pain as well as in the implementation of improved therapies for patients who continue to experience these devastating conditions.

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