

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

185,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Where We Come From and Are We Aware of Where We Are Going To?

*Vicente Vanaclocha, Nieves Saiz-Sapena,
José María Ortiz-Criado and Leyre Vanaclocha*

Abstract

Chronic pain is a pathological condition that requests specific medical attention. Its treatment has been imperative since the origin of our species, taking advantage of herbs and natural remedies available in the primitive environment. Morphine has stood the test of time as has been continuously used for the past 8 millennia. The anatomical knowledge of the nociceptive sensation pathways led to the introduction of some surgical techniques directed to stop this pain transmission. Due to their aggressiveness and to the fact that they are irreversible, these techniques were soon replaced by neurostimulation procedures. Being reversible and allowing a change in stimulation parameters soon became the preferred treatment strategy. Over the years a small subset of patients continues to suffer from chronic pain refractory to the usual neurostimulation and pain-controlling medications. These patients can perhaps benefit from one of the surgical ablative procedures. Some of these techniques have been proven particularly effective throughout the years. For some limited income patients in underdeveloped countries, these techniques may be their only accessible option. Doctors have to keep in mind these surgical techniques to put them at the service of our patients in the very few cases in which they are needed. Letting these ablative techniques to die in oblivion would be a disservice to our patients.

Keywords: chronic pain, chronic pain management, surgical techniques for chronic pain management, pain clinic

1. Introduction

Pain is a defensive mechanism essential for normal life [1]. It helps us to prevent, avoid or stop any potential or real damage to us [2]. Yet, it becomes a disease in itself once it transforms into a chronic condition, oftentimes when the disease that originated the pain is no longer present [3].

The word pain itself is a matter of interest. In Arabic there are hundreds of words to express it, while in European languages, this wealth of vocabulary does not exist, and different types of pain have to be expressed through a much limited number of words [4]. As a rule a language develops more words when it has to describe a bigger amount of details of single entity. This is the case for the word

snow in Eskimo-Aleut languages [5]. In fact it is known that the verbalization of pain can somehow change its same perception [6–8].

From the very beginning, humanity has looked for means to control pain using several vegetal preparations [9–13]. The use of morphine for pain control can be dated in Mesopotamia back to the sixth millennium before Christ [14, 15]. In the Roman times, it was commonly used [16], and Galen described the use of a morphine-based ointment for the treatment of a variety of medical conditions, including chronic pain [17]. This is probably the first description of transdermal morphine use and the first known antecedent of opioid transdermal patches. Apart from the treatment of pain, morphine was used for many other medical conditions due to its antitussive, antidiarrheal and hypnotic properties [15].

In Europe during the Middle Ages, morphine became an expensive item as it had to be brought from distant places in Asia, so few people could afford it [4, 18], and yet opium (vegetal preparation containing morphine) was part of several pharmaceutical preparations [19].

Addiction to morphine was already known in Roman times [16], but it became commonplace in the Renaissance, particularly among upper class individuals [14], as they were the ones who could afford it?

In 1680, Thomas Sydenham introduced the laudanum, a mixture of opium in sherry wine [4]. This made the administration of this drug much easier and its popularity rose. Consequently, opium became a lucrative product, and its trade led to conflict, escalating to wars such as those between China and Great Britain [20, 21].

In 1803, Sertürner isolated morphine crystals and paved the way to the use of this alkaloid instead of vegetal-derived products [4, 22]. This allowed its chemical characterisation and the creation of new drugs that improved specifically the antitussive, antidiarrheal and hypnotic properties of morphine [10]. Sertürner's work also allowed a more precise control of morphine doses being administered and thus a better control of side effects and overdose.

In the nineteenth century the first non-steroidal anti-inflammatory medications were discovered [10], and local and general anaesthesia were introduced [23]. These made morphine less important as it was no longer the only analgesic medication available.

Surgical treatment of chronic pain emerged after the anatomical pathways involved in pain transmission were discovered. Cordotomy, a procedure to lesion the pathways that transmit nociceptive sensation at the spinal cord level, was introduced in 1912 by Spiller and Martin [24] and was used until the mid-twentieth century [25–27]. It was performed initially as an open procedure but was later done percutaneously [28, 29]. Another pain control surgical technique was commissural myelotomy, but it was used much more sparingly [30, 31]. These ablative procedures were also attempted at higher levels like the brainstem and the thalamus [32].

The dorsal root entry zone (DREZ) lesion was introduced by Sindou [33] and Nashold [34] in the 1960s, and ever since it has been used in brachial plexus avulsion pain. DREZ is particularly successful for this specific medical condition and is still in use up to today [35–38].

Initially mostly surgeons [39] dealt with chronic pain, but subsequently the anaesthetists became involved [40], and the first pain clinics were created [41]. The idea was to integrate in a single unit all the specialities involved in the treatment of chronic pain [42, 43].

The introduction of the posterior spinal column stimulation in the 1970s [44] and the implanted morphine infusion systems in the 1980s [45] were revolutionary, and myelotomies, cordotomies and peripheral neurectomies were soon put aside [46, 47], as reversible procedures are often preferred above ablative lesions. With posterior spinal cord stimulation, if there is any trouble to the patient or

unsatisfactory results, the stimulation parameters could be modified, the stimulation stopped altogether, or the morphine dose increased. In case of failure, other management approaches could be considered [48]. In case of the implantable morphine infusion systems, they could be implanted with ease so that physicians other than surgeons could use them.

2. Current situation

Over the years, surgeons have lost interest and importance in most pain clinics [49]. The anaesthetists have taken over [50] and provided a large selection of minimally invasive techniques and revolutionised the percutaneous and oral management of chronic pain [51]. The surgical techniques of pain management have been slowly obliterated [52] in favour of those that involve peripheral or central nervous system stimulation [53, 54] and intrathecal or epidural drug administration [55–57]. In posterior spinal cord stimulation procedures, it has been proven that the surgically implanted pad electrodes provide better results than the needle-inserted ones [58]. This has strong implications on which specialty should implant the definitive posterior spinal column electrodes.

Opioids have become a common treatment strategy, available to the patients by means apart from doctor's prescriptions [59–61]. As a result, the morphine consumption per person has been increasing in the latest years [62] to reach what has been named an opioid epidemic [46, 63–67]. Sometimes the process starts after the prescription of opioids to treat acute pain, for example, after a surgical procedure, but patients get addicted to the drug, and then it becomes difficult to make them abandon their use [68–72]. Opioids are nowadays so widespread that they can be acquired in the illegal market [61, 73]. This means that patients can use them with little or no physician control [59, 60] suffering from unwanted serious side effects and even death [74–77].

3. Future trends

Some have urged the creation of new analgesics with stronger actions and less addictive effects [78]. Ziconotide is one of them but has the disadvantage that it can only be administered intrathecally [79–81]. Some toxin-derived peptide drugs have been analysed, but the results are not consistent [82], while drugs that interact with the cellular membrane potassium channels are also being investigated [83]. Some recombinant proteins have been studied in the experimental setting, but they have not yet reached the clinical study phase [84].

In the latest years, there seems to be a renewed interest in old surgical procedures to treat chronic pain, particularly for oncological patients [85]. Under this category are the cordotomy [24], the block of the *plexus coeliacus* [86], the *nervus splanchnicus* [87] or the *hypogastric nerve* [87] and the *vidian nerve* radiofrequency neurotomy [88], to mention a just few. It is currently used as a last resource for patients whose pain has not been controlled with other more conservative measures [85, 87, 89, 90]. Other procedures like the DREZ [38, 91], the zygapophyseal joint percutaneous rhizotomy [92] or the radiofrequency sacroiliac joint denervation [93] are still commonly used nowadays. Some old techniques have been improved and adapted to be minimally invasive, such as the radiofrequency thalamotomy [94, 95]. There are also new interesting additions, like the genicular nerve cooled radiofrequency neurotomy to treat chronic knee pain [96, 97], the obturator and femoral nerve sensory percutaneous neurotomy to deal with hip problems [98, 99], the shoulder pulsed radiofrequency of the suprascapular and axillary nerve to treat chronic pain shoulder [100, 101] or

the epicondyle radiofrequency treatment for chronic elbow pain [102, 103]. All these and other less common surgical procedures are there to be considered and used in selected cases [87, 104]. However the lack of interest of the surgeons in an area mostly controlled these days by the anaesthetists [49] has led to the oblivion of surgical techniques that could be of potential help to some patients, particularly in refractory cases in which all had previously failed [87]. We need to keep the knowledge of these surgical techniques that can be of potential interest to particularly refractory cases.

On the other hand, not all patients worldwide have access to the same options [105–108]. Economic issues can make some neurostimulative or implantable pump techniques unaffordable that might be advisable in a patient [109–111]. Nevertheless, some of the old surgical ablative procedures might be affordable [87, 112] as they have a much lower monetary cost [110] and may be beneficial for these patients. Hence, surgical control of pain has to remain a known alternative, sometimes preferable to long-term opioid use and its associated side effects [113].

The continuation of the study of the basic mechanisms of pain production, transmission, perception and induced suffering is imperative [114–117], as is the investigation of new treatment strategies. A very promising area is fibromyalgia [118, 119], a condition for which pathological studies are negative [120] in the affected individuals and yet they claim to be in constant pain. This also happens in other medical conditions such as schizophrenia, and nobody will dare to state that schizophrenia does not exist because it lacks a precise pathological correlate [121]. Recent studies have highlighted neurotransmitter changes in chronic pain that need to be thoroughly analysed and studied [122–124].

4. Situation in each hospital

Each country, each area and even each hospital pose a particular scenario. Over the years many neurosurgeons have lost interest in the chronic pain treatment and retreated from the pain clinics [49]. We need to change this trend and get more involved in this area [52], so that our capabilities can be requested when they could be of particular help, benefitting patients which lack viable alternatives.

This book is a plea to awaken physicians in some ablative procedures that should have never been forgotten.

5. Conclusions

Treatment of chronic pain demands a multidisciplinary approach. Everybody is welcomed and needed. In the latest years, anaesthetists have taken a big role in this arena, but surgeons need to keep ready for those uncommon cases in which everything fails. In some low-income countries or patients with refractory pain, some ablative procedures might be an option that their pockets can afford. Surgical techniques of chronic pain management should not fall into the oblivion. Continuous research is needed to better understand the chronic pain condition and to find new remedies against it.

IntechOpen

Author details

Vicente Vanaclocha^{1*}, Nieves Saiz-Sapena², José María Ortiz-Criado³
and Leyre Vanaclocha⁴

1 Department of Neurosurgery, Hospital General Universitario Valencia, Spain

2 Hospital 9 de Octubre, Valencia, Spain

3 Universidad Católica San Vicente Mártir, Valencia, Spain

4 Medical School, University College London, London, United Kingdom

*Address all correspondence to: vvanaclo@hotmail.com

IntechOpen

© 2019 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Han S, Soleiman MT, Soden ME, Zweifel LS, Palmiter RD. Elucidating an affective pain circuit that creates a threat memory. *Cell*. 2015;**162**:363-374
- [2] Tambeli CH, Fischer L, Monaliza SL, Menescal-de-Oliveira L, Parada CA. The functional role of ascending nociceptive control in defensive behavior. *Brain Research*. 2012;**1464**:24-29
- [3] Lamana MS, Miranda J, Tobaldini G, Fischer L, Tambeli CH. Pain chronification and chronic pain impair a defensive behavior, but not the ability of acute pain to facilitate it, through the activation of an endogenous analgesia circuit. *Behavioral Neuroscience*. 2018;**132**:614-623
- [4] Santoro D, Bellinghieri G, Savica V. Development of the concept of pain in history. *Journal of Nephrology*. 2011;**24**(Suppl 17):S133-S136
- [5] Regier T, Carstensen A, Kemp C. Languages support efficient communication about the environment: Words for snow revisited. *PLoS One*. 2016;**11**:e0151138
- [6] Junghaenel DU, Schneider S, Broderick JE. Linguistic indicators of pain catastrophizing in patients with chronic musculoskeletal pain. *The Journal of Pain*. 2017;**18**:597-604
- [7] Koban L, Jepma M, Geuter S, Wager TD. What's in a word? How instructions, suggestions, and social information change pain and emotion. *Neuroscience and Biobehavioral Reviews*. 2017;**81**:29-42
- [8] Robertson O, Robinson SJ, Stephens R. Swearing as a response to pain: A cross-cultural comparison of British and Japanese participants. *Scandinavian Journal of Pain*. 2017;**17**:267-272
- [9] Arablou T, Kolahdouz-Mohammadi R. Curcumin and endometriosis: Review on potential roles and molecular mechanisms. *Biomedicine & Pharmacotherapy*. 2018;**97**:91-97
- [10] Kaiser H. From the plant to chemistry—The early history of “rheumatic medication”. *Zeitschrift für Rheumatologie*. 2008;**67**:252-262
- [11] Pasero G, Marson P. A short history of anti-rheumatic therapy. II. Aspirin. *Reumatismo*. 2010;**62**:148-156
- [12] Tapsell LC, Hemphill I, Cobiack L, Patch CS, Sullivan DR, Fenech M, et al. Health benefits of herbs and spices: The past, the present, the future. *The Medical Journal of Australia*. 2006;**185**:S4-S24
- [13] Yang R, Yuan B-C, Ma Y-S, Zhou S, Liu Y. The anti-inflammatory activity of licorice, a widely used Chinese herb. *Pharmaceutical Biology*. 2017;**55**:5-18
- [14] Brook K, Bennett J, Desai SP. The chemical history of morphine: An 8000-year journey, from resin to de-novo synthesis. *Journal of Anesthesia History*. 2017;**3**:50-55
- [15] Presley CC, Lindsley CW. DARK classics in chemical neuroscience: Opium, a historical perspective. *ACS Chemical Neuroscience*. 2018;**9**:2503-2518
- [16] Trancas B, Borja Santos N, Patrício LD. The use of opium in Roman society and the dependence of Princeps Marcus Aurelius. *Acta Médica Portuguesa*. 2008;**21**:581-590
- [17] Harrison AP, Hansen SH, Bartels EM. Transdermal opioid patches for pain treatment in ancient Greece. *Pain Practice: The Official Journal of World Institute of Pain*. 2012;**12**:620-625
- [18] Mahdizadeh S, Khaleghi Ghadiri M, Gorji A. Avicenna's canon of medicine:

A review of analgesics and anti-inflammatory substances. *Avicenna Journal of Phytomedicine*. 2015;5:182-202

[19] Lopez-Munoz F, Garcia-Garcia P, Alamo C. The virtue of that precious balsam...: Approach to Don Quixote from the psychopharmacological perspective. *Actas Españolas de Psiquiatría*. 2007;35:149-220

[20] Baumann D. The opium war and its background, one of the darkest chapters of European cultural history. *Pharmazie*. 1953;8:303-305

[21] Inoue H. The opium war in the Ching dynasty. *Toyoshi Kenkyu*. 1982;41:58-83

[22] Duarte DF. Opium and opioids: A brief history. *Revista Brasileira de Anestesiologia*. 2005;55:135-146

[23] Zimmermann M. History of pain treatment from 1500 to 1900. *Der Schmerz*. 2007;21:297-306

[24] Teoli D, An J. Cordotomy. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2018. Available: <http://www.ncbi.nlm.nih.gov/books/NBK535446/>

[25] Graf CJ. Relief of chronic pain at the spinomedullary level. *The Journal of the International College of Surgeons*. 1965;43:622-629

[26] Tönnis W, Bischof W. Experiences in the transection of the pain pathway in the brain stem. *Deutsche Zeitschrift für Nervenheilkunde*. 1966;188:127-141

[27] Usbeck W. Chordotomy in treatment of chronic pain in cancer. *Zentralblatt für Chirurgie*. 1954;79:1101-1108

[28] Crue BL, Felsoory A. Transcutaneous high cervical "electrical cordotomy". *Minnesota Medicine*. 1974;57:204-209

[29] Lippe PM. Neurosurgery-epitomes of progress: Percutaneous radiofrequency cervical cordotomy: Treatment of chronic intractable pain. *The Western Journal of Medicine*. 1977;127:233-234

[30] Cook AW, Nathan PW, Smith MC. Sensory consequences of commissural myelotomy. A challenge to traditional anatomical concepts. *Brain: A Journal of Neurology*. 1984;107(Pt 2):547-568

[31] Pisco K. Open spinal operations (anterolateral chordotomy and commissural myelotomy) in modern treatment of pain (author's transl). *Langenbecks Archiv für Chirurgie*. 1976;342:91-99

[32] Getz B. Surgical interception of the central nervous pathways; Anatomical basis in therapy of pain. *Nordisk Medicin*. 1955;54:1585-1589

[33] Sindou M. Drez lesions for brachial plexus injury. *Neurosurgery*. 1988;23:528

[34] Nashold BS. Current status of the DREZ operation: 1984. *Neurosurgery*. 1984;15:942-944

[35] Awad AJ, Forbes JA, Jermakowicz W, Eli IM, Blumenkopf B, Konrad P. Experience with 25 years of dorsal root entry zone lesioning at a single institution. *Surgical Neurology International*. 2013;4:64

[36] Chivukula S, Tempel ZJ, Chen C-J, Shin SS, Gande AV, Moossy JJ. Spinal and nucleus caudalis dorsal root entry zone lesioning for chronic pain: Efficacy and outcomes. *World Neurosurgery*. 2015;84:494-504

[37] Ruiz-Juretschke F, García-Salazar F, García-Leal R, Fernández-Carballal C, Iza B, Garbizu JM, et al. Treatment of neuropathic deafferentation pain using DREZ lesions; long-term results. *Neurología*. 2011;26:26-31

- [38] Takai K, Taniguchi M. Modified dorsal root entry zone lesioning for intractable pain relief in patients with root avulsion injury. *Journal of Neurosurgery. Spine*. 2017;**27**:178-184
- [39] Hackett TP. The surgeon and the difficult pain problem. *International Psychiatry Clinics*. 1967;**4**:179-188
- [40] Swerdlow M. The role of the anesthetist in the treatment of chronic pain conditions (author's transl). *MMW, Münchener Medizinische Wochenschrift*. 1977;**119**:1527-1530
- [41] Lasagna L, Werner G. Conjoint clinic on pain and analgesia. *Journal of Chronic Diseases*. 1966;**19**:695-709
- [42] Crue BL, Pinsky JJ, Agnew DC, Malyon AK, Felsöőry A, Kenton B, et al. What is a pain center? *Bulletin of the Los Angeles Neurological Societies*. 1976;**41**:160-167
- [43] Miles J. The neurosurgeon in the pain clinic. *British Journal of Neurosurgery*. 1989;**3**:629-631
- [44] Hoppenstein R. Percutaneous implantation of chronic spinal cord electrodes for control of intractable pain: Preliminary report. *Surgical Neurology*. 1975;**4**:195-198
- [45] Harbaugh RE, Coombs DW, Saunders RL, Gaylor M, Pageau M. Implanted continuous epidural morphine infusion system. Preliminary report. *Journal of Neurosurgery*. 1982;**56**:803-806
- [46] Pergolizzi JV, LeQuang JA, Taylor R, Raffa RB, NEMA Research Group. Going beyond prescription pain relievers to understand the opioid epidemic: The role of illicit fentanyl, new psychoactive substances, and street heroin. *Postgraduate Medicine*. 2018;**130**:1-8
- [47] van Roost D, Gybels J. Myelotomies for chronic pain. *Acta Neurochirurgica. Supplementum (Wien)*. 1989;**46**:69-72
- [48] Lazorthes Y, Verdie JC, Arbus L. Anterior and posterior medullary analgesic stimulation, using a percutaneous implantation technic. *Acta Neurochirurgica*. 1978;**40**:277-283
- [49] Gatchel RJ, McGeary DD, McGeary CA, Lippe B. Interdisciplinary chronic pain management: Past, present, and future. *The American Psychologist*. 2014;**69**:119-130
- [50] Timerbaev VK, Genov PG. Role of anesthesiologist in chronic pain management. *Anesteziologiya i Reanimatologiya*. 2016;**61**:128-130
- [51] Mu A, Weinberg E, Moulin DE, Clarke H. Pharmacologic management of chronic neuropathic pain: Review of the Canadian pain society consensus statement. *Canadian Family Physician*. 2017;**63**:844-852
- [52] Poppler LH, Mackinnon SE. The role of the peripheral nerve surgeon in the treatment of pain. *Neurotherapeutics*. Jan 2019;**16**(1):9-25
- [53] Farrell SM, Green A, Aziz T. The current state of deep brain stimulation for chronic pain and its context in other forms of neuromodulation. *Brain Sciences*. 2018;**8**:E158
- [54] Maheshwari A, Pope JE, Deer TR, Falowski S. Advanced methods of spinal stimulation in the treatment of chronic pain: Pulse trains, waveforms, frequencies, targets and feedback loops. *Expert Review of Medical Devices*. 2019;**16**(2):95-106
- [55] Bruel BM, Burton AW. Intrathecal therapy for cancer-related pain. *Pain Medicine*. 2016;**17**:2404-2421

- [56] Deer TR, Pope JE, Hanes MC, McDowell GC. Intrathecal therapy for chronic pain: A review of morphine and ziconotide as firstline options. *Pain Medicine*. Aug 2018. DOI: 10.1093/pm/pny132. [Epub ahead of print]
- [57] Prager J, Deer T, Levy R, Bruel B, Buchser E, Caraway D, et al. Best practices for intrathecal drug delivery for pain. *Neuromodulation Journal International Neuromodulation Society*. 2014;**17**:354-372; discussion 372
- [58] Hussaini SMQ, Murphy KR, Han JL, Elsamadicy AA, Yang S, Premji A, et al. Specialty-based variations in spinal cord stimulation success rates for treatment of chronic pain. *Neuromodulation Journal International Neuromodulation Society*. 2017;**20**:340-347
- [59] Cheng T, Small W, Dong H, Nosova E, Hayashi K, DeBeck K. An age-based analysis of nonmedical prescription opioid use among people who use illegal drugs in Vancouver, Canada. *Substance Abuse Treatment, Prevention, and Policy*. 2018;**13**:41
- [60] Mackey TK, Kalyanam J, Katsuki T, Lanckriet G. Twitter-based detection of illegal online sale of prescription opioid. *American Journal of Public Health*. 2017;**107**:1910-1915
- [61] Soelberg CD, Brown RE, Du Vivier D, Meyer JE, Ramachandran BK. The US opioid crisis: Current federal and state legal issues. *Anesthesia and Analgesia*. 2017;**125**:1675-1681
- [62] Silbermann M. Opioids in middle eastern populations. *Asian Pacific Journal of Cancer Prevention*. 2010;**1**:1-5
- [63] Bernard SA, Chelminski PR, Ives TJ, Ranapurwala SI. Management of pain in the United States-a brief history and implications for the opioid epidemic. *Health Services Insights*. 2018;**11**:1178632918819440
- [64] Carey ET. Opioids misuse and abuse: The making of a national opioid epidemic. *Clinical Obstetrics and Gynecology*. 2019 Jan 5. DOI: 10.1097/GRF.0000000000000426
- [65] Clark DJ, Schumacher MA. America's opioid epidemic: Supply and demand considerations. *Anesthesia and Analgesia*. 2017;**125**:1667-1674
- [66] Rummans TA, Burton MC, Dawson NL. How good intentions contributed to bad outcomes: The opioid crisis. *Mayo Clinic Proceedings*. 2018;**93**:344-350
- [67] Trecki J. A perspective regarding the current state of the opioid epidemic. *JAMA Network Open*. 2019;**2**:e187104
- [68] Erstad BL. Attempts to limit opioid prescribing in critically ill patients: Not so easy, not so fast. *The Annals of Pharmacotherapy*. Jan 13 2019:1060028018824724. DOI: 10.1177/1060028018824724. [Epub ahead of print]
- [69] Hah JM, Bateman BT, Ratliff J, Curtin C, Sun E. Chronic opioid use after surgery: Implications for perioperative management in the face of the opioid epidemic. *Anesthesia and Analgesia*. 2017;**125**:1733-1740
- [70] Hirji SA, Landino S, Cote C, Lee J, Orhurhu V, Shah RM, et al. Chronic opioid use after coronary bypass surgery. *Journal of Cardiac Surgery*. Feb 2019;**34**(2):67-73
- [71] Lian X, Adsumelli R, Griffin TR, Gan TJ. Clinical updates in women's health care summary: Perioperative pain management: Primary and Preventive Care Review. *Obstetrics & Gynecology*. 2018;**132**:1321

- [72] Mark J, Argentieri DM, Gutierrez CA, Morrell K, Eng K, Hutson AD, et al. Ultrarestrictive opioid prescription protocol for pain management after gynecologic and abdominal surgery. *JAMA Network Open*. 2018;**1**:e185452
- [73] Sjøgren P, Rindom H. The medicine and drug-abusing patient. *Ugeskrift for Laeger*. 2006;**168**:4317-4319
- [74] Colon-Berezin C, Nolan ML, Blachman-Forshay J, Paone D. Overdose deaths involving fentanyl and fentanyl analogs-New York City, 2000-2017. *Morbidity and Mortality Weekly Report*. 2019;**68**:37-40
- [75] Gaither JR, Shabanova V, Leventhal JM. US national trends in pediatric deaths from prescription and illicit opioids, 1999-2016. *JAMA Network Open*. 2018;**1**:e186558
- [76] Scholl L, Seth P, Kariisa M, Wilson N, Baldwin G. Drug and opioid-involved overdose deaths-United States, 2013-2017. *MMWR. Morbidity and Mortality Weekly Report*. 2018;**67**:1419-1427
- [77] VanHouten JP, Rudd RA, Ballesteros MF, Mack KA. Drug overdose deaths among women aged 30-64 years-United States, 1999-2017. *MMWR. Morbidity and Mortality Weekly Report*. 2019;**68**(1):-5
- [78] Stein C. Pain inhibition by opioids-new concepts. *Anaesthesist*. Feb 2019;**68**(2):97-103
- [79] Bäckryd E. Do the potential benefits outweigh the risks? An update on the use of ziconotide in clinical practice. *European Journal of Pain*. 2018;**22**:1193-1202
- [80] McDowell GC, Pope JE. Intrathecal ziconotide: Dosing and administration strategies in patients with refractory chronic pain. *Neuromodulation Journal International Neuromodulation Society*. 2016;**19**:522-532
- [81] Wie CS, Derian A. Ziconotide. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2018. Available: <http://www.ncbi.nlm.nih.gov/books/NBK459151/>
- [82] Stepensky D. Pharmacokinetics of toxin-derived peptide drugs. *Toxins*. 2018;**10**(11). pii: E483. DOI: 10.3390/toxins10110483
- [83] Gada K, Plant LD. Two-pore domain potassium channels: Emerging targets for novel analgesic drugs: IUPHAR Review 26. *British Journal of Pharmacology*. 2019;**176**:256-266
- [84] Prado J, Popov-Celeketic J, Steen-Louws C, Raoof R, Hack E, Eijkelkamp N. Development of recombinant proteins to treat chronic pain. *Journal of Visualized Experiments*. Apr 2018;**11**(134). DOI: 10.3791/57071
- [85] Fontaine D, Vandersteen C, Magis D, Lanteri-Minet M. Neuromodulation in cluster headache. *Advances and Technical Standards in Neurosurgery*. 2015;**42**:3-21
- [86] Ashlock K. Celiac plexus block: Management of abdominal pain in patients with late-stage cancer. *Clinical Journal of Oncology Nursing*. 2018;**22**:663-665
- [87] Vissers KCP, Besse K, Wagemans M, Zuurmond W, Giezeman MJMM, Lataster A, et al. 23. Pain in patients with cancer. *Pain Practice: The Official Journal of World Institute of Pain*. 2011;**11**:453-475
- [88] Liu S-C, Kao M-C, Huang Y-C, Su W-F. Vidian neurectomy for management of chronic cluster headache. *Neurosurgery*. 2018 Dec 10. DOI: 10.1093/neuros/nyy136. [Epub ahead of print]
- [89] Collins KL, Taren JA, Patil PG. Four-decade maintenance of analgesia with percutaneous cordotomy.

Stereotactic and Functional
 Neurosurgery. 2012;**90**:266-272

- [90] Menon JP. Intracranial ablative procedures for the treatment of chronic pain. *Neurosurgery Clinics of North America*. 2014;**25**:663-670
- [91] Son B-C, Choi J-G, Ha S-W, Kim D-R. Intraoperative neurophysiological monitoring (motor and somatosensory evoked potentials) in dorsal root entry zone lesioning for brachial plexus avulsion pain. *Stereotactic and Functional Neurosurgery*. 2017;**95**:330-340
- [92] Starr JB, Gold L, McCormick Z, Suri P, Friedly J. Trends in lumbar radiofrequency ablation utilization from 2007 to 2016. *The Spine Journal*. 2019
- [93] Bayerl SH, Finger T, Heiden P, Esfahani-Bayerl N, Topar C, Prinz V, et al. Radiofrequency denervation for treatment of sacroiliac joint pain-comparison of two different ablation techniques. *Neurosurgical Review*. 2018 Jul 31. DOI: 10.1007/s10143-018-1016-3. [Epub ahead of print]
- [94] Roberts DG, Pouratian N. Stereotactic radiosurgery for the treatment of chronic intractable pain: A systematic review. *Operative Neurosurgery*. 2017;**13**:543-551
- [95] Young RF, Jacques DS, Rand RW, Copcutt BR. Medial thalamotomy with the Leksell Gamma Knife for treatment of chronic pain. *Acta Neurochirurgica. Supplement*. 1994;**62**:105-110
- [96] Jadon A, Jain P, Motaka M, Swarupa CP, Amir M. Comparative evaluation of monopolar and bipolar radiofrequency ablation of genicular nerves in chronic knee pain due to osteoarthritis. *Indian Journal of Anaesthesia*. 2018;**62**:876-880
- [97] Mata J, Valentí P, Hernández B, Mir B, Aguilar JL. Study protocol

- for a randomised controlled trial of ultrasound-guided pulsed radiofrequency of the genicular nerves in the treatment of patients with osteoarthritis knee pain. *BMJ Open*. 2017;**7**:e016377
- [98] Bhatia A, Hoydonckx Y, Peng P, Cohen SP. Radiofrequency procedures to relieve chronic hip pain: An evidence-based narrative review. *Regional Anesthesia and Pain Medicine*. 2018;**43**:72-83
- [99] Kim JH, Shin SH, Lee YR, Lee HS, Chon JY, Sung CH, et al. Ultrasound-guided peripheral nerve stimulation for neuropathic pain after brachial plexus injury: Two case reports. *Journal of Anesthesia*. 2017;**31**:453-457
- [100] Liu A, Zhang W, Sun M, Ma C, Yan S. Evidence-based status of pulsed radiofrequency treatment for patients with shoulder pain: A systematic review of randomized controlled trials. *Pain practice : The official journal of World Institute of Pain*. 2016;**16**:518-525
- [101] Yan J, Zhang X-M. A randomized controlled trial of ultrasound-guided pulsed radiofrequency for patients with frozen shoulder. *Medicine*. 2019;**98**:e13917
- [102] Hamlin K, Munro C, Barker SL, McKenna S, Kumar K. Open release versus radiofrequency microtenotomy in the treatment of lateral epicondylitis: A prospective randomized controlled trial. *Shoulder and Elbow*. 2018;**10**:45-51
- [103] Tasto JP, Cummings J, Medlock V, Hardesty R, Amiel D. Microtenotomy using a radiofrequency probe to treat lateral epicondylitis. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*. 2005;**21**:851-860
- [104] Sharim J, Pouratian N. Anterior cingulotomy for the treatment of chronic intractable pain: A systematic review. *Pain Physician*. 2016;**19**:537-550

- [105] Asgeirsdottir TL, Birgisdottir KH, Ólafsdóttir T, Olafsson SP. A compensating income variation approach to valuing 34 health conditions in Iceland. *Economics and Human Biology*. 2017;**27**:167-183
- [106] Doualla M, Aminde J, Aminde LN, Lekpa FK, Kwedi FM, Yenshu EV, et al. Factors influencing disability in patients with chronic low back pain attending a tertiary hospital in sub-Saharan Africa. *BMC Musculoskeletal Disorders*. 2019;**20**(25)
- [107] Hardman R, Lawn S, Tsourtos G. Pain self-management: Easier said than done? Factors associated with early dropout from pain self-management in a rural primary care population. *Pain Medicine*. 2018 Sep 6. DOI: 10.1093/pm/pny167. [Epub ahead of print]
- [108] Kieselbach K, Schiltenswolf M, Bozzaro C. Chronic pain care: Reality and entitlement. *Der Schmerz*. 2016;**30**:351-357
- [109] Hoelscher C, Riley J, Wu C, Sharan A. Cost-effectiveness data regarding spinal cord stimulation for low back pain. *Spine*. 2017;**42**(Suppl 14):S72-S79
- [110] Kim EK, Shin JY, Castañeda AM, Lee SJ, Yoon HK, Kim YC, et al. Retrospective analysis of the financial break-even point for intrathecal morphine pump use in Korea. *Korean Journal of Pain*. 2017;**30**:272-280
- [111] Newman AK, Kapoor S, Thorn BE. Health care utilization for chronic pain in low-income settings. *Pain Medicine*. 2018;**19**:2387-2397
- [112] Manchikanti L, Pampati V, Kaye AD, Hirsch JA. Therapeutic lumbar facet joint nerve blocks in the treatment of chronic low back pain: Cost utility analysis based on a randomized controlled trial. *Korean Journal of Pain*. 2018;**31**:27-38
- [113] Turner BJ, Rodriguez N, Bobadilla R, Hernandez AE, Yin Z. Chronic pain self-management program for low-income patients: Themes from a qualitative inquiry. *Pain Medicine*. 2018
- [114] Gimenez C, Zafra F, Aragon C. Pathophysiology of the glutamate and the glycine transporters: New therapeutic targets. *Revista de Neurologia*. 2018;**67**:491-504
- [115] Kremer M, Yalcin I, Goumon Y, Wurtz X, Nexon L, Daniel D, et al. A dual noradrenergic mechanism for the relief of neuropathic allodynia by the antidepressant drugs duloxetine and amitriptyline. *Journal of Neuroscience: The Official Journal of the Society for Neuroscience*. 2018;**38**:9934-9954
- [116] Nagakura Y. The need for fundamental reforms in the pain research field to develop innovative drugs. *Expert Opinion on Drug Discovery*. 2017;**12**:39-46
- [117] Sheng J, Liu S, Wang Y, Cui R, Zhang X. The link between depression and chronic pain: Neural mechanisms in the brain. *Neural Plasticity*. 2017;**2017**:9724371
- [118] Gostine M, Davis F, Roberts BA, Risko R, Asmus M, Cappelleri JC, et al. Clinical characteristics of fibromyalgia in a chronic pain population. *Pain Practice: The Official Journal of World Institute of Pain*. 2018;**18**:67-78
- [119] Sluka KA, Clauw DJ. Neurobiology of fibromyalgia and chronic widespread pain. *Neuroscience*. 2016;**338**:114-129
- [120] Grayston R, Czanner G, Elhadd K, Goebel A, Frank B, Üçeyler N, et al. A systematic review and meta-analysis of the prevalence of small fiber pathology in fibromyalgia: Implications for a new paradigm in fibromyalgia etiopathogenesis. *Seminars in Arthritis and Rheumatism*. 2018 Aug 23. pii:

S0049-0172(18)30363-9. DOI: 10.1016/j.semarthrit.2018.08.003. [Epub ahead of print]

[121] Yukawa T, Iwakura Y, Takei N, Saito M, Watanabe Y, Toyooka K, et al. Pathological alterations of chondroitin sulfate moiety in postmortem hippocampus of patients with schizophrenia. *Psychiatry Research*. 2018;**270**:940-946

[122] Berna C, Leknes S, Ahmad AH, Mhuirheartaigh RN, Goodwin GM, Tracey I. Opioid-independent and opioid-mediated modes of pain modulation. *Journal of Neuroscience: The Official Journal of the Society for Neuroscience*. 2018;**38**:9047-9058

[123] Khouzam HR. Psychopharmacology of chronic pain: A focus on antidepressants and atypical antipsychotics. *Postgraduate Medicine*. 2016;**128**:323-330

[124] Taylor BK, Westlund KN. The noradrenergic locus coeruleus as a chronic pain generator. *Journal of Neuroscience Research*. 2017;**95**:1336-1346