Open Journal of Anesthesiology, 2024, 14, 185-195
https://www.scirp.org/journal/ojanes
ISSN Online: 2164-5558
ISSN Print: 2164-5531

# Regional Block Anesthesia in Breast Surgery: What Do We Know So Far?

**Hao Wang[1]*, Sharat Chopra[2], Prit Anand Singh[1]**

[1]Department of Anesthesia & Surgical Intensive Care, Changi General Hospital, Simei, Singapore
[2]Department of Surgery, Aneurin Bevan University Health Board, Newport, UK
Email: *wang.hao@singhealth.com.sg

**How to cite this paper:** Wang, H., Chopra, S. and Singh, P.A. (2024) Regional Block Anesthesia in Breast Surgery: What Do We Know So Far? *Open Journal of Anesthesiology*, **14**, 185-195.
https://doi.org/10.4236/ojanes.2024.149017

**Received:** August 5, 2024
**Accepted:** September 10, 2024
**Published:** September 13, 2024



## Abstract

Breast cancer is the most prevalent cancer in women worldwide, and pain following mastectomy is a major post-surgical complication. This paper highlights the risk factors for chronic pain in breast surgery and evaluates various regional block techniques used to reduce post-operative pain, and minimize hospital stays in high-risk patients. Further research is needed to evaluate the effectiveness of novel regional anaesthesia techniques in an enhanced recovery context, and to assess their role in preventing or reducing chronic pain.

## Keywords

Chronic Pain, Breast Surgery, Mastectomy, Regional Anesthesia, Nerve Blocks, Ultrasound-Guided

## 1. Introduction

Breast cancer is the most common cancer in women globally, affecting approximately one in seven women [1]. Breast cancer treatment often involves surgical procedures, including mastectomy (with or without breast reconstruction) or breast conservation surgery. Pain following mastectomy has long been recognized as a clinically significant complication. Patients often describe postmastectomy pain as a dull, burning, or aching sensation affecting the chest, axilla, and ipsilateral upper extremity [2]. This condition is often referred to as Postmastectomy Syndrome [3], which can affect up to 50% or more of women following breast cancer surgeries [4] [5]. With time, breast cancer prognosis is improving due to advances in diagnosis and treatment [6] [7]. Minimizing chronic pain and its long-term effects has become crucial for breast cancer survivors. Careful patient screening for chronic pain risk, deliberate use of multimodal analgesia (including regional anesthesia techniques), and close follow-up after surgery, chemotherapy or radiotherapy, are vital components in the care of breast surgery patients. This paper highlights the risk factors for chronic pain in breast surgery and evaluates various regional anesthesia block techniques used to reduce post-operative pain and minimize hospital stays in high-risk patients.

## 2. Predisposing Risk Factors for Chronic Pain in Breast Surgery

The following have been recognized as risk factors for the development of chronic pain after breast surgery:

- Younger patient [8]-[10];
- Higher immediate post-operative pain scores [9] [11];
- Preoperative or underlying painful conditions such as fibromyalgia [11] [12];
- Ethnicity and socioeconomic factors—commonly seen in Black or Hispanic population [13];
- Extent/stage of breast disease [14];
- Psychological factors such as anxiety and depression [15] [16];
- Poor pain control [17];
- Genetic risk factors- opioid receptor alteration- mu-opioid receptor abnormality [18];
- Axillary dissection [9] [19];
- Mastectomy or breast conservation [20];
- Radiation therapy [21] [22].

## 3. Breast Anatomy and Planes for Anesthesia

The breast and the adjacent chest wall contain multiple neural and interfascial planes through which regional anesthesia can provide substantial anesthesia. The relevant anatomy can be described based on their cutaneous/subcutaneous and muscular innervations.

The spinal nerves at the thoracic level divide into their dorsal and ventral rami; the dorsal rami provide innervation to the posterior chest wall and are of little relevance for breast surgery. However, the ventral rami run within the paravertebral space and emerge as the intercostal nerves [23]. These nerves pass through the fascial plane between the internal and innermost intercostal muscles. The lateral cutaneous branch emerges from this fascial plane at the mid-axillary line, piercing the internal intercostal, external intercostal and serratus anterior muscles. After division, the lateral cutaneous branch of the intercostal nerve provides innervation to the lateral chest wall, and the anterior cutaneous branch emerges in proximity to the sternum, providing innervation to the medial chest and sternum. The nipple-areola complex has an elaborate and disputed innervation. The cranial portion of the breast derives its innervation from supraclavicular nerves, the branches of the Superficial Cervical plexus. The axilla (innervation for the Tail of Spence and the axillary lymph nodes) is supplied predominantly by the intercostobrachial nerve, formed from the lateral cutaneous branch of the T2 ventral rami (Figure 1).

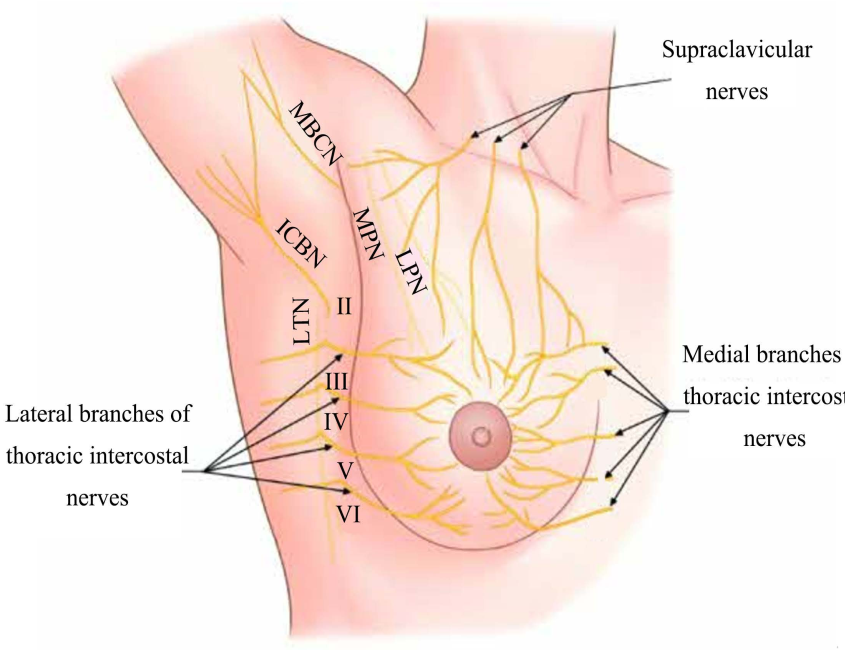


Figure 1. Diagrammatic representation of the nerves innervating the female breast and axilla. MPN, medial pectoral nerve; LPN, lateral pectoral nerve; MBCN, medial brachial cutaneous nerve; ICBN, intercostobrachial nerve; LTN, long thoracic nerve [24].

Regional blocks were previously underutilized in breast surgery. Today, the widespread adoption of ultrasound imaging during the perioperative period has provided the anesthesiologists with real-time visualization advantages, allowing more advanced regional blocks to be performed in a precise manner. This has also led to the development of novel regional block techniques, particularly fascial plane blocks, which allow local anesthetic to spread across multiple planes and block multiple nerves simultaneously.

## 4. Regional Block Anesthesia Techniques

Table 1 below summarizes various techniques for regional anesthesia for breast surgery. These can also be used for other thoracic area/wall surgeries since the nerve supply remains similar.

Table 1. Regional nerve blocks used for breast surgery.

| Regional blocks | Area of blockade | Target Nerves | Effect/duration | Adverse effects | Recommendation |
|---|---|---|---|---|---|
| Paravertebral block | Paravertebral space | Intercostal n., dorsal rami, rami communicantes, sympathetic chain | 6 - 8 hours; option of continuous infusion via catheter | Sympathetic blockade, hemodynamic instability, breach of intrathecal space, pleural puncture | Contraindicated in anticoagulated patients |

**Continued**

| | | | | | |
|---|---|---|---|---|---|
| Pectoral blocks | Interfascial planes between pec major, pec minor and serratus anterior muscles | Lateral and medial pectoral nerves, upper intercostal nerves, long thoracic nerve | Up to 24 - 36 hours, dependent on drugs/adjuvants use | Fewer significant side effects, potential intravascular spread by the pectoral branch of the thoracoacromial artery | Comparable pain score and the opioid requirement to PVB with a better safety profile |
| Serratus plane block (SPB) | Planes above and below the serratus anterior muscle | Lateral branches of Intercostal nerves, intercostobrachial, thoracodorsal and long thoracic nerves | Up to 24 - 36 hours, dependent on drugs/adjuvants use | More advanced needling skills are required; a higher volume of LA is needed; proximity to pleura (pneumothorax) | Antero-lateral and partial posterior chest wall; potential advantage in breast reconstruction with latissimus dorsi flap |
| Pectointercostal fascial block | Plane between pectoralis major and external intercostal muscle | Anterior cutaneous branches of intercostal nerves | Up to 24 - 36 hours, dependent on drugs/adjuvants use | Further from pleura and internal thoracic vessels | Supplements are spared by Pectoral blocks and SPB |
| Transversus thoracic muscle plane block | Plane between transversus thoracis and internal intercostal muscle | Anterior branches of intercostal nerves | Up to 24 - 36 hours, dependent on drugs/adjuvants use | Proximity to internal thoracic vessels, pleura, and pericardium | It has been used for acute and chronic pain |

1) ***Thoracic Paravertebral block*** (***TPVB***)

This technique involves injecting local anesthetic (LA) into the thoracic paravertebral space. The LA spreads across multiple levels, effectively blocking the thoracic-spinal nerves as they exit the intervertebral foramina. Some LA may spread laterally into the intercostal space, and medially into the epidural space. LA spread within the paravertebral space results in ipsilateral blockade of somatic and sympathetic nerves of the thoracic region [25]. There is substantial literature that supports the use of TPVB in breast surgery for reducing post-operative pain, opioid use, and nausea and vomiting [26]-[29]. TPVB is effective as a perioperative analgesic and can even provide surgical anesthesia [23]. The use of paravertebral catheters has been recommended to prolong post-operative analgesia in a recent PROSPECT guideline. Research has demonstrated that single-level TPVB is quicker, less labor-intensive, and equally effective compared to the multiple-injection approach or using paravertebral catheters. It is worth noting that TPVB cannot reliably provide analgesia to the axilla (T1 nerve distribution), and supplemental LA infiltration to the area may be required [30] [31].

2) ***Pectoral Blocks*** (***PECS***)

Over the last decade, the PECS blocks (PECS I and PECS II blocks) have gained prominence for providing analgesia for thoracic wall procedures. They are a group of ultrasound-guided interfascial plane blocks targeting the nerves between the pectoralis major muscle (pec major), pectoralis minor muscle (pec minor) and serratus anterior muscle (SAM) [32] [33]. The inter-pectoral plane block (formerly known as PECS I block) involves injecting LA between the pec major and pec minor muscles, while the pecto-serratus plane block (known as PECS II block) involves injecting LA between the pec minor muscle and the SAM. They have been shown to reduce pain scores and opioid use in the first 12 hours, resulting in shorter Post-anesthesia Care Unit (PACU) stays as well as overall hospital stay [34].

An additional modification of the pecto-serratus plane block suggests performing the injection deep (rather than superficial) to the SAM. This approach may enhance inter-fascial spread, but more importantly, it helps spare the long thoracic nerve, which allows early assessment of nerve function, particularly in cases where there is a risk of neural damage during surgical dissection. Recently published meta-analyses comparing the pecto-serratus plane block with TPVB found no differences in pain scores or opioid consumption. Pecto-serratus plane block was not inferior to TPVB in reducing pain intensity and morphine consumption after surgery. Both were superior to systemic analgesia alone [35] [36]. Compared to TPVB, the pecto-serratus plane block is a peripheral technique with a lower risk of sympathetic blockade and significant bleeding.

**3) *Serratus Anterior plane block* (*SPB*)**

The serratus anterior plane block (SPB) is performed more distal and lateral to the pecto-serratus plane block, with LA injection in the interfascial plane superficial and deep to SAM. The advantage of this approach is its proximity to the intercostal nerves, resulting in effective analgesia/anesthesia for the ipsilateral the chest wall [37] [38].

A recent meta-analysis found that patients who received SPB had lower pain scores and lower 24-hour opioid requirements post-operatively compared to non-block care. A comparison between SPB and TPVB showed no differences in post-operative pain scores or opioid requirements; however, this comparison was based on five trials only, and there were issues with blinding and the heterogeneity of the data sets [39].

**4) *Pecto-intercostal fascia block* (*PIFB*)**

This ultrasound-guided block is performed on the medial aspect of the breast at the level of the fourth rib, just lateral to the sternal border. Once the ribs, pleura, and intercostal space are identified, the block needle is advanced in the cranial-to-caudal direction into the interfascial plane between the pectoralis major and external intercostal muscles, where the LA is deposited. This supplementary block is not typically used as a standalone technique for breast surgery [40].

**5) *Transversus thoracis plane block* (*TTP block*)**

This relatively new ultrasound-guided nerve block technique provides analgesia for the medial anterior chest wall. It is a single shot fascial plane block where the LA is deposited between the transversus thoracis and internal intercostal muscles, commonly performed between the third and fourth ribs. Precise needle placement, ultrasound guidance, and awareness of anatomical landmarks are crucial, as complications may arise due proximity to the pleura, the pericardium on the left, and internal thoracic artery within the space. A recent double-blinded study involving cardiac patients demonstrated superior early post-operative pain control with lower opioid consumption compared to the control group [41]. However, no data is available for breast surgeries.

**6) *Erector spinae plane* (*ESP*) *block***

In the ESP block, LA is deposited deep to the erector spinae muscles in the upper thoracic vertebrae (T2 - T5). The technique was initially described by Forero *et al.* in 2016 [42] and has since gained a meteoric rise in popularity in a wide range of clinical applications. Its various mechanisms of action have been eloquently discussed by Chin *et al.* in 2021 [43]. The block can be utilized either as a single-shot technique for immediate pain relief or by inserting a catheter to provide continuous analgesia after surgery or trauma.

In the context of breast cancer surgery, two randomized control studies comparing ESP block with general anesthesia alone demonstrated significantly lower morphine consumption in the early postoperative period among patients who received ESP block, although there was no notable difference in pain scores [44] [45]. A separate study comparing ESP block to PECS block did not show significant disparity in pain scores immediately after surgery; however, after the first hour post-surgery, it became evident that patients who received PECS block reported significantly lower pain scores and used fewer opioids [46].

**7) *Local Anesthetic* (*LA*) *wound infiltration***

LA wound infiltration is commonly administered by breast surgeons as a mode of post-operative analgesia. However, it provides limited analgesia, and the effect may not last longer than 24 hours [47]. Nevertheless, LA wound infiltration does have a role in complementing regional analgesia techniques such as PECS and TPVB, which may not always provide adequate analgesia to the T1 nerve distribution.

**8) *Liposomal Bupivacaine***

Liposomal Bupivacaine is a newer drug used in regional anesthesia. It has a longer duration of action of up to 3 - 4 days, compared to plain Bupivacaine which typically lasts less than 24 hours [48]. Preliminary evidence suggests that Liposomal Bupivacaine may hold promise for longer reconstructive breast surgeries. However, further studies comparing outcomes and costs are necessary to establish its full efficacy and cost-effectiveness.

## 5. Discussion

Widespread adoption of ultrasound imaging technologies in recent years has led to increased popularity of ultrasound-guided regional anesthesia techniques in breast cancer surgery, even as novel techniques are being developed. Studies comparing combined regional and general anesthesia to general anesthesia alone consistently demonstrate superior post-operative analgesia, leading to faster recovery and shorter hospital stays. Regional anesthesia also reduces the complications associated with opioids, such as constipation, nausea, and vomiting. Not all patients are suitable candidates for regional anesthesia, such as those with coagulation disorders, sepsis, a history of anaphylaxis to LA agents, and other specific conditions. Complications of regional anesthesia techniques include block failure, nerve damage, vascular injury, adjacent organ injury, and systemic toxicity. However, in skilled hands the benefits of regional anesthesia outweigh the risks in most cases.

Regional anesthesia can also be employed as a sole technique for breast surgery, including mastectomy and axillary node clearance. Sedation can be used to supplement regional techniques, minimizing anxiety and ensuring patient comfort. Regional only technique is particularly beneficial in high-risk, estrogen-negative breast cancer patients with complicated medical history and among those who want to avoid general anesthesia. It has the advantages of superior analgesia and faster recovery, while avoiding most of the complications of general anesthesia, such as post-operative nausea and vomiting, sore throat, dental damage, and cardiorespiratory complications. Patients can be discharged to surgical high care or general wards instead of HDU or ITU, thus reducing the need for critical care beds and often strained hospital resources.

An interesting development about the role of local anesthetic in reducing breast cancer recurrence came in the form of a recent study looking at the impact of presurgical, peritumoral infiltration of local anesthesia on disease-free survival. Patients with early breast cancer planned for upfront surgery without prior neoadjuvant treatment were randomly assigned to receive a peritumoral injection of 0.5% lidocaine before surgery [49]. Results from this study suggested that the use of lidocaine significantly increases disease-free survival and overall survival, and that altering events at the time of surgery can prevent metastases in early breast cancer.

## 6. Conclusion

In breast cancer surgery, regional anesthesia techniques such as the thoracic paravertebral or pectoral nerves blocks, within a multimodal analgesia approach, are effective in reducing postoperative pain and opioid consumption. Post-operative analgesia duration can be further extended with the use of continuous nerve block catheters. In patients considered high-risk for general anesthesia, regional anesthesia may be employed as a sole technique for breast surgery. Further research is needed to evaluate the effectiveness of novel regional anesthesia techniques in an enhanced recovery context, and to assess their role in preventing or reducing chronic pain.

## Conflicts of Interest

The authors declare no conflicts of interest or finance regarding the publication of this paper.

## References

[1] https://breastcancernow.org/about-us/why-we-do-it/breast-cancer-facts-and-

statistics/

[2] Wood, K.M. (1978) Intercostobrachial Nerve Entrapment Syndrome. *Southern Medical Journal*, **71**, 662-663. https://doi.org/10.1097/00007611-197806000-00016

[3] Hokkam, E. (2015) Postmastectomy Pain Syndrome: A Frequent Problem Facing Cancer Surgeons. *Journal of Surgery*, **3**, 18-22. https://doi.org/10.11648/j.js.s.2015030201.14

[4] Alves Nogueira Fabro, E., Bergmann, A., do Amaral e Silva, B., Padula Ribeiro, A.C., de Souza Abrahão, K., da Costa Leite Ferreira, M.G., *et al.* (2012) Post-Mastectomy Pain Syndrome: Incidence and Risks. *The Breast*, **21**, 321-325. https://doi.org/10.1016/j.breast.2012.01.019

[5] Vadivelu, N., Schreck, M., Lopez, J., Kodumudi, G. and Narayan, D. (2008) Article Commentary: Pain after Mastectomy and Breast Reconstruction. *The American Surgeon*, **74**, 285-296. https://doi.org/10.1177/000313480807400402

[6] Howlader, N., Noone, A.M., Krapcho, M., *et al.* (2021) SEER Cancer Statistics Review, 1975-2018. National Cancer Institute.

[7] Berry, D.A., Cronin, K.A., Plevritis, S.K., Fryback, D.G., Clarke, L., Zelen, M., *et al.* (2005) Effect of Screening and Adjuvant Therapy on Mortality from Breast Cancer. *New England Journal of Medicine*, **353**, 1784-1792. https://doi.org/10.1056/nejmoa050518

[8] Mejdahl, M.K., Andersen, K.G., Gartner, R., Kroman, N. and Kehlet, H. (2013) Persistent Pain and Sensory Disturbances After Treatment for Breast Cancer: Six Year Nationwide Follow-Up Study. *BMJ*, **346**, f1865. https://doi.org/10.1136/bmj.f1865

[9] Andersen, K.G., Duriaud, H.M., Jensen, H.E., Kroman, N. and Kehlet, H. (2015) Predictive Factors for the Development of Persistent Pain after Breast Cancer Surgery. *Pain*, **156**, 2413-2422. https://doi.org/10.1097/j.pain.0000000000000298

[10] Kehlet, H., Jensen, T.S. and Woolf, C.J. (2006) Persistent Postsurgical Pain: Risk Factors and Prevention. *The Lancet*, **367**, 1618-1625. https://doi.org/10.1016/s0140-6736(06)68700-x

[11] Wang, L., Guyatt, G.H., Kennedy, S.A., Romerosa, B., Kwon, H.Y., Kaushal, A., *et al.* (2016) Predictors of Persistent Pain after Breast Cancer Surgery: A Systematic Review and Meta-Analysis of Observational Studies. *Canadian Medical Association Journal*, **188**, E352-E361. https://doi.org/10.1503/cmaj.151276

[12] Langford, D.J., Schmidt, B., Levine, J.D., Abrams, G., Elboim, C., Esserman, L., *et al.* (2015) Preoperative Breast Pain Predicts Persistent Breast Pain and Disability after Breast Cancer Surgery. *Journal of Pain and Symptom Management*, **49**, 981-994. https://doi.org/10.1016/j.jpainsymman.2014.11.292

[13] Eversley, R., Estrin, D., Dibble, S., Wardlaw, L., Pedrosa, M. and Favila-Penney, W. (2005) Post-Treatment Symptoms among Ethnic Minority Breast Cancer Survivors. *Oncology Nursing Forum*, **32**, 250-256. https://doi.org/10.1188/05.onf.250-256

[14] Steiner, C.A., Weiss, A.J., Barrett, M.L., Fingar, K.R. and Davis, P.H. (2016) Trends in Bilateral and Unilateral Mastectomies in Hospital Inpatient and Ambulatory Settings, 2005-2013. HCUP Statistical Brief #201. Agency for Healthcare Research and Quality. https://hcup-us.ahrq.gov/reports/statbriefs/sb201-Mastectomies-Inpatient-Outpatient.pdf?utm_source-=AHRQ&utm_medium=Press-Release&utm_content=1&utm_term=18&utm_cam-paign=AHRQ_MIG

[15] Masselin-Dubois, A., Attal, N., Fletcher, D., Jayr, C., Albi, A., Fermanian, J., *et al.* (2013) Are Psychological Predictors of Chronic Postsurgical Pain Dependent on the Surgical Model? A Comparison of Total Knee Arthroplasty and Breast Surgery for Cancer. *The Journal of Pain*, **14**, 854-864. https://doi.org/10.1016/j.jpain.2013.02.013

[16] Rief, W., Bardwell, W.A., Dimsdale, J.E., Natarajan, L., Flatt, S.W. and Pierce, J.P. (2011) Long-Term Course of Pain in Breast Cancer Survivors: A 4-Year Longitudinal Study. *Breast Cancer Research and Treatment*, **130**, 579-586. https://doi.org/10.1007/s10549-011-1614-z

[17] Schreiber, K.L., Martel, M.O., Shnol, H., Shaffer, J.R., Greco, C., Viray, N., *et al.* (2013) Persistent Pain in Postmastectomy Patients: Comparison of Psychophysical, Medical, Surgical, and Psychosocial Characteristics between Patients with and without Pain. *Pain*, **154**, 660-668. https://doi.org/10.1016/j.pain.2012.11.015

[18] Belfer, I., Young, E.E. and Diatchenko, L. (2014) Letting the Gene out of the Bottle. *Anesthesiology*, **121**, 678-680. https://doi.org/10.1097/aln.0000000000000404

[19] Mansel, R.E., Fallowfield, L., Kissin, M., Goyal, A., Newcombe, R.G., Dixon, J.M., *et al.* (2006) Randomized Multicenter Trial of Sentinel Node Biopsy versus Standard Axillary Treatment in Operable Breast Cancer: The ALMANAC Trial. *JNCI*: *Journal of the National Cancer Institute*, **98**, 599-609. https://doi.org/10.1093/jnci/djj158

[20] Marfizo, S., Thornton, A., Scott, N., Thompson, A., Hays, S. and Bruce, J. (2010) Intensity and Features of Acute Postoperative Pain after Mastectomy and Breast-Conserving Surgery. *Breast Cancer Research*, **12**, P56. https://doi.org/10.1186/bcr2553

[21] Gärtner, R., Jensen, M., Nielsen, J., Ewertz, M., Kroman, N. and Kehlet, H. (2009) Prevalence of and Factors Associated with Persistent Pain Following Breast Cancer Surgery. *JAMA*, **302**, 1985-1992. https://doi.org/10.1001/jama.2009.1568

[22] Langford, D.J., Paul, S.M., West, C., Levine, J.D., Hamolsky, D., Elboim, C., *et al.* (2014) Persistent Breast Pain Following Breast Cancer Surgery Is Associated with Persistent Sensory Changes, Pain Interference, and Functional Impairments. *The Journal of Pain*, **15**, 1227-1237. https://doi.org/10.1016/j.jpain.2014.08.014

[23] Woodworth, G.E., Ivie, R.M.J., Nelson, S.M., Walker, C.M. and Maniker, R.B. (2017) Perioperative Breast Analgesia: A Qualitative Review of Anatomy and Regional Techniques. *Regional Anesthesia and Pain Medicine*, **42**, 609-631. https://doi.org/10.1097/aap.0000000000000641

[24] Kim, D., Kim, S., Kim, C.S., Lee, S., Lee, I., Kim, H.J., *et al.* (2018) Efficacy of Pectoral Nerve Block Type II for Breast-Conserving Surgery and Sentinel Lymph Node Biopsy: A Prospective Randomized Controlled Study. *Pain Research and Management*, **2018**, Article ID: 4315931. https://doi.org/10.1155/2018/4315931

[25] Karmakar, M.K. (2001) Thoracic Paravertebral Block. *Anesthesiology*, **95**, 771-780. https://doi.org/10.1097/00000542-200109000-00033

[26] Schnabel, A., Reichl, S.U., Kranke, P., Pogatzki-Zahn, E.M. and Zahn, P.K. (2010) Efficacy and Safety of Paravertebral Blocks in Breast Surgery: A Meta-Analysis of Randomized Controlled Trials. *British Journal of Anaesthesia*, **105**, 842-852. https://doi.org/10.1093/bja/aeq265

[27] Parikh, R.P. and Myckatyn, T.M. (2018) Paravertebral Blocks and Enhanced Recovery after Surgery Protocols in Breast Reconstructive Surgery: Patient Selection and Perspectives. *Journal of Pain Research*, **11**, 1567-1581. https://doi.org/10.2147/jpr.s148544

[28] Chiu, M., Bryson, G.L., Lui, A., Watters, J.M., Taljaard, M. and Nathan, H.J. (2013) Reducing Persistent Postoperative Pain and Disability 1 Year after Breast Cancer Surgery: A Randomized, Controlled Trial Comparing Thoracic Paravertebral Block to Local Anesthetic Infiltration. *Annals of Surgical Oncology*, **21**, 795-801. https://doi.org/10.1245/s10434-013-3334-6

[29] Ilfeld, B.M., Madison, S.J., Suresh, P.J., Sandhu, N.S., Kormylo, N.J., Malhotra, N., *et al.* (2014) Persistent Postmastectomy Pain and Pain-Related Physical and Emotional

Functioning with and without a Continuous Paravertebral Nerve Block: A Prospective 1-Year Follow-Up Assessment of a Randomized, Triple-Masked, Placebo-Controlled Study. *Annals of Surgical Oncology*, **22**, 2017-2025. https://doi.org/10.1245/s10434-014-4248-7

[30] Pawa, A., Wight, J., Onwochei, D.N., Vargulescu, R., Reed, I., Chrisman, L., *et al.* (2018) Combined Thoracic Paravertebral and Pectoral Nerve Blocks for Breast Surgery under Sedation: A Prospective Observational Case Series. *Anaesthesia*, **73**, 438-443. https://doi.org/10.1111/anae.14213

[31] Jacobs, A., Lemoine, A., Joshi, G.P., Van de Velde, M. and Bonnet, F. (2020) PROSPECT Guideline for Oncological Breast Surgery: A Systematic Review and Procedure-specific Postoperative Pain Management Recommendations. *Anaesthesia*, **75**, 664-673. https://doi.org/10.1111/anae.14964

[32] Blanco, R. (2011) The "Pecs Block": A Novel Technique for Providing Analgesia after Breast Surgery. *Anaesthesia*, **66**, 847-848. https://doi.org/10.1111/j.1365-2044.2011.06838.x

[33] Hussain, N., Brull, R., McCartney, C.J.L., Wong, P., Kumar, N., Essandoh, M., *et al.* (2019) Pectoralis-II Myofascial Block and Analgesia in Breast Cancer Surgery: A Systematic Review and Meta-Analysis. *Anesthesiology*, **131**, 630-648. https://doi.org/10.1097/aln.0000000000002822

[34] Bashandy, G.M.N. and Abbas, D.N. (2015) Pectoral Nerves I and II Blocks in Multimodal Analgesia for Breast Cancer Surgery: A Randomized Clinical Trial. *Regional Anesthesia and Pain Medicine*, **40**, 68-74. https://doi.org/10.1097/aap.0000000000000163

[35] Versyck, B., van Geffen, G. and Chin, K. (2019) Analgesic Efficacy of the Pecs II Block: A Systematic Review and Meta-Analysis. *Anaesthesia*, **74**, 663-673. https://doi.org/10.1111/anae.14607

[36] Zhao, J., Han, F., Yang, Y., Li, H. and Li, Z. (2019) Pectoral Nerve Block in Anesthesia for Modified Radical Mastectomy: A Meta-Analysis Based on Randomized Controlled Trials. *Medicine*, **98**, e15423. https://doi.org/10.1097/md.0000000000015423

[37] Blanco, R., Parras, T., McDonnell, J.G. and Prats-Galino, A. (2013) Serratus Plane Block: A Novel Ultrasound-Guided Thoracic Wall Nerve Block. *Anaesthesia*, **68**, 1107-1113. https://doi.org/10.1111/anae.12344

[38] Khemka, R., Chakraborty, A., Ahmed, R., Datta, T. and Agarwal, S. (2016) Ultrasound-Guided Serratus Anterior Plane Block in Breast Reconstruction Surgery. *A & A Case Reports*, **6**, 280-282. https://doi.org/10.1213/xaa.0000000000000297

[39] Chong, M., Berbenetz, N., Kumar, K. and Lin, C. (2019) The Serratus Plane Block for Postoperative Analgesia in Breast and Thoracic Surgery: A Systematic Review and Meta-Analysis. *Regional Anesthesia & Pain Medicine*, rapm-2019-100982. https://doi.org/10.1136/rapm-2019-100982

[40] de la Torre, P.A., Garcia, P.D., Alvarez, S.L., Miguel, F.J.G. and Perez, M.F. (2014) A Novel Ultrasound-Guided Block: A Promising Alternative for Breast Analgesia. *Aesthetic Surgery Journal*, **34**, 198-200. https://doi.org/10.1177/1090820x13515902

[41] Aydin, M.E., Ahiskalioglu, A., Ates, I., Tor, I.H., Borulu, F., Erguney, O.D., *et al.* (2020) Efficacy of Ultrasound-Guided Transversus Thoracic Muscle Plane Block on Postoperative Opioid Consumption after Cardiac Surgery: A Prospective, Randomized, Double-Blind Study. *Journal of Cardiothoracic and Vascular Anesthesia*, **34**, 2996-3003. https://doi.org/10.1053/j.jvca.2020.06.044

[42] Forero, M., Adhikary, S.D., Lopez, H., Tsui, C. and Chin, K.J. (2016) The Erector Spinae Plane Block: A Novel Analgesic Technique in Thoracic Neuropathic Pain.

*Regional Anesthesia and Pain Medicine*, **41**, 621-627.
https://doi.org/10.1097/aap.0000000000000451

[43] Chin, K.J. and El-Boghdadly, K. (2021) Mechanisms of Action of the Erector Spinae Plane (ESP) Block: A Narrative Review. *Canadian Journal of Anesthesia*, **68**, 387-408.
https://doi.org/10.1007/s12630-020-01875-2

[44] Gürkan, Y., Aksu, C., Kuş, A., Yörükoğlu, U.H. and Kılıç, C.T. (2018) Ultrasound Guided Erector Spinae Plane Block Reduces Postoperative Opioid Consumption Following Breast Surgery: A Randomized Controlled Study. *Journal of Clinical Anesthesia*, **50**, 65-68. https://doi.org/10.1016/j.jclinane.2018.06.033

[45] Singh, S., Kumar, G. and Akhileshwar, (2019) Ultrasound-Guided Erector Spinae Plane Block for Postoperative Analgesia in Modified Radical Mastectomy: A Randomised Control Study. *Indian Journal of Anaesthesia*, **63**, 200-204.
https://doi.org/10.4103/ija.ija_758_18

[46] Altıparmak, B., Korkmaz Toker, M., Uysal, A.İ., Turan, M. and Gümüş Demirbilek, S. (2019) Comparison of the Effects of Modified Pectoral Nerve Block and Erector Spinae Plane Block on Postoperative Opioid Consumption and Pain Scores of Patients after Radical Mastectomy Surgery: A Prospective, Randomized, Controlled Trial. *Journal of Clinical Anesthesia*, **54**, 61-65.
https://doi.org/10.1016/j.jclinane.2018.10.040

[47] Byager, N., Hansen, M.S., Mathiesen, O. and Dahl, J.B. (2014) The Analgesic Effect of Wound Infiltration with Local Anaesthetics after Breast Surgery: A Qualitative Systematic Review. *Acta Anaesthesiologica Scandinavica*, **58**, 402-410.
https://doi.org/10.1111/aas.12287

[48] Vyas, K.S., Rajendran, S., Morrison, S.D., Shakir, A., Mardini, S., Lemaine, V., *et al.* (2016) Systematic Review of Liposomal Bupivacaine (Exparel) for Postoperative Analgesia. *Plastic & Reconstructive Surgery*, **138**, 748e-756e.
https://doi.org/10.1097/prs.0000000000002547

[49] Badwe, R.A., Parmar, V., Nair, N., Joshi, S., Hawaldar, R., Pawar, S., *et al.* (2023) Effect of Peritumoral Infiltration of Local Anesthetic before Surgery on Survival in Early Breast Cancer. *Journal of Clinical Oncology*, **41**, 3318-3328.
https://doi.org/10.1200/jco.22.01966