Abstract: Breast surgery is exceedingly common and may result in significant acute as well as chronic pain. Numerous options exist for the control of perioperative breast pain, including several newly described regional anesthesia techniques, but anesthesiologists have an insufficient understanding of the anatomy of the breast, the anatomic structures disrupted by the various breast surgeries, and the theoretical and experimental evidence supporting the use of the various analgesic options. In this article, we review the anatomy of the breast, common breast surgeries and their potential anatomic sources of pain, and analgesic techniques for managing perioperative pain. We performed a systematic review of the evidence for these analgesic techniques, including intercostal block, epidural administration, paravertebral block, brachial plexus block, and novel peripheral nerve blocks. (Reg Anesth Pain Med 2017;42: 609–631)

Surgeries of the breast are among the most common operative procedures, and numerous options exist for perioperative anesthesia and analgesia that can affect acute perioperative pain, persistent pain, and potentially cancer recurrence. Patients who undergo breast surgery experience significant acute pain, but are also at risk of chronic pain. Up to 55% of postmastectomy patients experience chronic pain persisting for months to years.1–5 One of the best predictors of chronic pain following breast surgery is the amount of perioperative pain experienced by the patient.6–12 Although multiple options exist for control of perioperative breast surgery pain, including several newly described regional anesthesia techniques, there is insufficient understanding of the anatomy of the breast, the anatomic structures disrupted by the various breast surgeries, and the theoretical and experimental evidence supporting the use of the various analgesic options. In part I of this article, we review the anatomy of the breast and common breast surgeries, along with the potential anatomic sources of perioperative pain. In part II, we present a systematic review of the evidence for the analgesic techniques including multimodal analgesia, local anesthetic infiltration, intercostal block, epidural administration, paravertebral block (PVB), brachial plexus block, and novel peripheral nerve blocks. METHODS


Articles were included if they met the following inclusion criteria: (1) randomized controlled trial (RCT) design; (2) participants were humans at least 18 years of age undergoing elective surgery on the breast (not including biopsy); (3) published in English and full text available; (4) analgesic interventions were intercostal block, interpleural block, epidural block, PVB, or novel peripheral nerve blocks; (5) outcome measures were postoperative analgesic consumption, postoperative pain scores, or duration of postoperative analgesia; and (6) minimum Jadad score of 2. Article titles and abstracts were screened, full-text articles were reviewed, and risk-of-bias assessments were performed by 2 authors independently (R.M.J.J. and R.B.M.), with any discrepancies resolved through discussion. Risk of bias was assessed using the 5-point scale described by Jadad et al.13 Articles using a study design other than RCT but meeting all other inclusion criteria were subsequently reviewed for findings not yet confirmed in RCTs.

The search strategy captured 5418 articles, of which 4407 were excluded. Of the remaining 1011 articles, 4407 were eliminated for failure to meet the inclusion criteria based on their titles and abstracts. Full-text review of the remaining 1011 articles eliminated an additional 965 articles that failed to meet the inclusion criteria, yielding a total of 46 articles (Fig. 1). Articles were organized according to intervention: 5 intercostal block, 0 interpleural block, 5 epidural block, 31 PVB, 1 brachial plexus block, and 4 novel peripheral nerve block.

DISCUSSION

Part I: Anatomy of the Breast, Surgical Disruption, and the Anatomic Basis for Regional Analgesia Techniques

Innervation of the Breast and Superficial Tissues

Several distinct nerves innervate the breast and surrounding tissues. The majority of the cutaneous sensation to the breast is derived from the intercostal nerves. Upon exiting the intervertebral foramina, the thoracic spinal nerves divide into dorsal and ventral rami. The dorsal rami innervate the skin and muscles over the...
medial back (Fig. 2). The ventral rami pass through the paravertebral space and become the intercostal nerves, which travel in the intercostal space just below the inferior border of the superior rib and are accompanied by an intercostal vein and artery. Much like the abdominal musculature, the intercostal region is composed of 3 muscle planes. From superficial to deep, the muscular planes are formed by the external intercostal muscle, the internal or intermediate intercostal muscle, and an innermost layer composed of the subcostal (posterior), innermost intercostal, and transversus thoracis (anterior) muscles. The intercostal nerves travel in the plane between the innermost layer and the internal intercostal muscle (Fig. 2). Near the midpoint between the spine and sternum, at approximately the angle of the rib and midaxillary line, a lateral cutaneous branch arises from the intercostal nerve and pierces the internal intercostal, external intercostal, and serratus anterior muscles (SAMs). The lateral cutaneous branches then divide into anterior and posterior divisions that provide cutaneous innervation to the lateral chest (Figs. 2–4). The continuation of the intercostal nerve terminates as an anterior cutaneous branch (ACB) by piercing the fascial extension of the external intercostal muscle close to the lateral edge of the sternum, providing cutaneous innervation to the medial chest and sternum (Figs. 2–4). In many texts, the anterior division of the lateral cutaneous branch is referred to as the anterior branch. We have used the term “anterior division” in order to avoid confusion with the terminal portion of the intercostal nerve, the ACB.

The breast is essentially a subcutaneous organ that receives innervation from anterior and lateral cutaneous branches of intercostal nerves, as well as supraclavicular nerves. Published descriptions of the specific nerves involved and their courses vary significantly, likely because of both anatomic variability and differences in research methodology. The most commonly described pattern of innervation of the medial breast is by the ACBs of the T2 through T5 intercostal nerves with variable involvement of T1 and T6 and innervation of the lateral breast by the lateral cutaneous branches of the T2 through T5 intercostal nerves with variable involvement of T1, T6, and T7 (Figs. 3, 4). The first intercostal nerve rarely gives off a lateral cutaneous branch. Both the lateral and anterior branches of different intercostal nerves frequently communicate with each other throughout their course, producing a variable pattern of innervation that does not adhere to strict dermatomal segmentation.

The relationship of the cutaneous nerves of the breast to the underlying muscles is important as surgeons must avoid these nerves, and anesthesiologists seek to block them. After piercing
termed the eral cutaneous branch arising from the T2 intercostal nerve, with variable contribution from T2 and T5. The exact innervation of the anterior and lateral branches of the intercostal nerves T3 through T4, over the lateral edge of the pectoralis major (PM) muscle to reach the breast.17 cutaneous branches may also give rise to a deep branch that the cutaneous tissue of the chest (Figs. 3, 4). The T4 and T5 lateral branches of the ACBs.17 The nipple-areola complex (NAC) is innervated by both anterior and lateral branches of the intercostal nerves T3 through T4, with variable contribution from T2 and T5. The exact innervation of the NAC is still controversial because of numerous anatomic variations and the difficulty in dissecting this area. The most common descriptions of NAC innervation detail a comingling of the terminal branches of the anterior divisions of the lateral cutaneous branches of the T4 and T5 intercostal nerves and the terminal branches of the ACBs.17–19,22

Special consideration should be given to the course of the lateral cutaneous branch arising from the T2 intercostal nerve, termed the intercostobrachial nerve. As with the other lateral cutaneous branches, this nerve branches off the intercostal nerve around the angle of the rib. The lateral aspect of the T2 rib lies in the axilla. After piercing the intercostal and SAMs, the majority of the lateral cutaneous branch of T2 travels laterally along the floor of the base of the axilla to reach the upper medial arm (Fig. 5). The intercostobrachial nerve provides cutaneous innervation to the axillary tail of the breast, the axilla, and the medial upper arm. The extrathoracic anatomy of this nerve is highly variable. It may receive contributions from other intercostal branches (T1, T3, and even T4) and can have a variety of anastomoses with branches of the brachial plexus, including the medial antebrachial cutaneous nerve, posterior cutaneous nerve of the forearm, and rarely with the pectoral nerves.23–25 This nerve is often implicated in postmastectomy pain, particularly after axillary dissection or lymph node sampling.26,27 Its variable anatomy may account for the conflicting reports of post–nerve injury symptoms.

In addition to the innervation of the breast tissue and skin, from the intercostal nerves, a small portion of the superior breast skin may be innervated by the supraclavicular nerves, although this description has been disputed.16,17,28 These nerves originate from the superficial cervical plexus and eventually travel in the subcutaneous tissue to pass over the clavicle and reach the superior aspect of the breast (Figs. 3, 4).

**Innervation of the Chest Wall**

Although the cutaneous innervation of the breast is derived from the intercostal nerves with a small contribution from the supraclavicular nerves, the brachial plexus supplies the innervation to the muscles of the chest wall (other than the intercostal muscles, which derive their innervation from the intercostal nerves). The majority of the breast tissue is immediately anterior to the pectoralis muscles. The upper portion of the PM muscle is supplied by the lateral pectoral nerve (LPN), whereas the medial pectoral nerve (MPN) innervates the pectoralis minor (Pm) muscle and the lower portion of PM.29,30 These nerves arise from the brachial plexus at variable locations and take a variable course

![Figure 2](image2.png)  
**FIGURE 2.** Course of the intercostal nerves. The ventral rami of the thoracic spinal nerves form the intercostal nerves, which travel in the intercostal space just below the inferior border of the superior rib. The intercostal region is composed of 3 muscle planes. From superficial to deep, the muscular planes are formed by the external intercostal, the internal or intermediate intercostal muscle, and an innermost layer composed of the subcostal, innermost intercostal, and transversus thoracis muscles. The intercostal nerves travel in the plane between the innermost layer and the internal intercostal muscle. Near the midpoint between the spine and sternum, a lateral cutaneous branch arises from each intercostal nerve and pierces the internal intercostal, external intercostal, and SAMs. The lateral cutaneous branches then divide into anterior and posterior divisions that provide cutaneous innervation to the lateral chest. The continuation of each intercostal nerve terminates as an ACB by piercing the fascial extension of the external intercostal muscle close to the lateral edge of the sternum, providing cutaneous innervation to the medial chest and sternum. Br indicates branch; div, division; m, muscle.

![Figure 3](image3.png)  
**FIGURE 3.** Innervation of the breast. Medially, the ACBs of the intercostal nerves can be seen piercing the PM near the sternum to innervate the medial breast. The supraclavicular nerves cross the clavicle and innervate the skin inferior to the clavicle and potentially a portion of the superior pole of the breast. The lateral cutaneous branches of the intercostal nerves divide into anterior and posterior divisions, which pierce the SAM. The anterior divisions provide innervation to the lateral breast. Also depicted are the posterior divisions, which can be seen entering the subcutaneous tissue to innervate the lateral chest wall. The lateral cutaneous branch of T2 forms the intercostobrachial nerve, which innervates the axilla and the medial upper arm. Br indicates branch; div, division; m, muscle; n, nerve.
Vision of the upper trunk of the brachial plexus or from the lateral pectoralis muscles. The serratus anterior at different locations. The supraclavicular nerves can be seen traveling caudally to innervate the superior chest. These nerves may reach the superior pole of the breast tissue, which overlays the second or third rib. On the lateral chest wall, the divisions of the lateral cutaneous branches of the intercostal nerves can be seen piercing the deep surface of the PM muscle and supplying its innervation before coursing anteriorly to the PM muscle, supplying its innervation, before coursing anteriorly to innervate the superior and medial aspect of the muscle. The MPN usually travels deep (posterior) to the PM muscle, supplying its innervation, before coursing anteriorly to supply innervation to the inferior portion of the PM. The MPN may pierce the PM muscle or emerge from beneath the inferior edge of the muscle to reach the PM, or both. Although these nerves do not innervate the subcutaneous tissue of the breast, they still play an important role in breast surgical pain. Disruption, stretching, or spasms of the pectoral muscles or associated fascia can be a significant source of myofascial pain after breast surgery.

The TDN is derived from the C6–8 nerve roots and arises most frequently from the anterior division of the fifth LCB exited through the serratus anterior (SA) muscle. Most of the anterior divisions of the fifth LCB exited through the serratus anterior at different locations. R1–R5 indicates first to fifth ribs; SA, serratus anterior; SCN, supraclavicular nerves.

The TDN is derived from the C6–8 nerve roots and arises from the posterior cord of the brachial plexus. It exits the posterior wall of the axilla to travel along the anterior and lateral portion of the latissimus dorsi (LD), and the LTN, which innervates the SA muscle. The MPN usually travels deep (posterior) to the PM muscle, supplying its innervation, before coursing anteriorly to innervate the superior and medial aspect of the muscle. The MPN usually travels deep (posterior) to the PM muscle, supplying its innervation, before coursing anteriorly to supply innervation to the inferior portion of the PM. The MPN may pierce the PM muscle or emerge from beneath the inferior edge of the muscle to reach the PM, or both. Although these nerves do not innervate the subcutaneous tissue of the breast, they still play an important role in breast surgical pain. Disruption, stretching, or spasms of the pectoral muscles or associated fascia can be a significant source of myofascial pain after breast surgery.
Excisional Breast Surgery

Lumpectomy involves excision of a wedge of subcutaneous breast tissue. A partial (segmental or quadrantectomy) mastectomy is performed if more breast tissue warrants removal. This procedure is performed for tumors that are too large for lumpectomy, for patients who cannot tolerate radiation, or if more than 1 distinct area of the breast is involved. As with a lumpectomy, only subcutaneous breast tissue is removed. Depending on whether surgery is performed medial or lateral to the nipple, the anterior or lateral cutaneous branches of the intercostal nerves (respectively) will contribute to the innervation of the operative area. A total (simple) mastectomy involves removing the entire subcutaneous breast tissue and varying amounts of overlying skin. The underlying fascia of the PM muscle is not disrupted. Similar to lumpectomies and partial mastectomies, the intercostal nerves are responsible for the innervation to the surgical area. When developing a plan for perioperative analgesia, it is important to determine if an axillary dissection or sentinel node biopsy will be performed in conjunction with a partial or total mastectomy. Surgery in the axilla is in the territory of the intercostobrachial nerve (lateral cutaneous branch of T2), which may require separate blockade, depending on the chosen anesthetic approach.

A radical mastectomy is a more extensive breast cancer operation involving removal of the entire breast, nipple, axillary lymph nodes, and pectoralis muscles. More commonly, a mastectomy and sentinel node biopsy are performed, or alternatively, a modified radical mastectomy, which includes a mastectomy and an axillary dissection but preserves the pectoralis muscles, is performed. The borders of dissection extend superiorly to the clavicle, medially to the sternum, inferiorly to the most caudal extent of breast tissue (on the costal margin below the inframammary fold), and laterally in the axilla to the border of the latissimus dorsi. The fascia of the PM muscle forms the deep margin of the dissection and is removed during the procedure, which may constitute a source of postoperative myofascial pain. The dissection also frequently involves removal of breast tissue or lymph nodes that reside between the inferior edge of the PM muscle and the Pm muscle. This is important as the MPN can be injured, resulting in partial denervation of the PM muscle. In addition, manipulation and stretching of the pectoralis muscles may be another source of perioperative myofascial pain. One or 2 drains may be placed through separate inferior-lateral incisions and can be additional sources of pain below the dermatoomes associated with the breast. Mastectomy requires general anesthesia or an advanced regional block with sedation. In contrast to pain from simple mastectomy, brachial plexus–derived nerves (lateral and medial pectoral, thoracodorsal, long thoracic) can also contribute to perioperative modified radical mastectomy pain (Fig. 7).

Reconstructive Breast Surgery

Because of the disfiguring nature of breast cancer surgery, surgical reconstruction to restore a natural breast appearance is frequently performed in conjunction with breast cancer procedures. In reconstructions with an implant, a tissue expander is usually placed beneath the PM muscle and anterior to the Pm. Laterally, the SAM may be elevated to cover the inferolateral pole of the implant. The inflatable bladder is expanded over days to weeks to slowly stretch the overlying PM muscle, fascia, and skin. In a second operation, the temporary expander is replaced by a long-term implant. It is important to identify whether a tissue expander will be placed after a total mastectomy. Unlike total mastectomy without a tissue expander, this procedure will involve blunt dissection of a pocket for the expander between the pectoral muscles. Creation of the pocket can be a source of additional periprocedural and chronic pain due to direct disruption of the pectoral nerves or lateral cutaneous branches of the intercostal nerves.

Breast Surgery and Tissue Disruption

Knowledge of the precise anatomic location of tissue disruption for each type of breast surgery is imperative in developing a perioperative analgesic plan. Operations involving the breast can differ substantially with regard to the tissues that are removed or compromised. Breast cancer procedures are discussed first.

Tumor Excision

A total (simple) mastectomy involves removing the entire subcutaneous breast tissue and varying amounts of overlying skin. The underlying fascia of the PM muscle is not disrupted. Similar to lumpectomies and partial mastectomies, the intercostal nerves are responsible for the innervation to the surgical area. When developing a plan for perioperative analgesia, it is important to determine if an axillary dissection or sentinel node biopsy will be performed in conjunction with a partial or total mastectomy. Surgery in the axilla is in the territory of the intercostobrachial nerve (lateral cutaneous branch of T2), which may require separate blockade, depending on the chosen anesthetic approach.

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or due to stretching or injury to the fascia of the serratus anterior or pectoral muscles. Women who undergo breast cancer surgery with immediate reconstruction have a higher prevalence of chronic pain when compared with women who undergo mastectomy without reconstruction (49% and 31%, respectively).\(^{12}\) An important consideration in developing a perioperative analgesic plan for breast surgery with reconstruction is the involvement of not only the intercostal nerves, but also the pectoral nerves and possibly the LTN (Fig. 7).

With implant reconstruction, a sheet of mesh or acellular dermal matrix is often used to provide internal support to the implant and to extend the lower border of the PM muscle. This allows the muscle to be held in place against the chest wall at the desired inframammary fold and provides an additional source of coverage material for the lower pole of the implant. This material is sewn directly to the chest wall, with sutures placed in rib peristeam or deep chest wall fascia, often creating a significant source of postoperative discomfort. Analgesia is targeted to the level of the sixth and seventh intercostal spaces (at the level of the inframammary fold) to address pain from these sutures.

Another type of reconstruction, either delayed or immediate, involves a free or pedicle flap to recreate breast volume.\(^{45}\) The most common procedures include transverse rectus abdominis myocutaneous flaps, either performed as a pedicled or free flap; deep inferior epigastric artery perforator as a free flap; and latissimus dorsi myocutaneous flaps as a pedicled flap. When developing a perioperative analgesic plan, the donor site for the flap must be considered in addition to the breast surgery itself. For example, a patient undergoing total mastectomy with immediate pedicled transverse rectus abdominis myocutaneous flap reconstruction may experience more postoperative pain from the abdominal wall donor site than from the mastectomy site.\(^{46,47}\) This is due to the resection of the rectus muscle and closure of the rectus sheath (primarily or with synthetic mesh).

When a traditional latissimus dorsi flap is used for breast reconstruction, an ellipse of skin is harvested from the back over the lower thoracic region to act as the donor site. The entire latissimus muscle is then elevated from a pocket that extends subcutaneously from the mid–lumbar region inferiorly to the tip of the scapula superiorly and from the paraspinous muscle fascia medially to the posterior axillary line laterally. If intercostal blocks are performed proximal to the origin of the intercostal nerves, the flap may pass through a tunnel near the axilla to the anterior chest. Any indwelling anesthetic catheter would need to cover the entire hemiback to the posterior midline on the side of the flap. It is also important to note that this muscle is innervated by the TDN, a branch of the brachial plexus.

**Breast Augmentation**

Mammoplasty refers to a group of procedures aimed at changing the shape and/or size of the breast, typically by augmentation or reduction. In primary breast augmentation, implants are generally placed via 1 of 4 skin incisions: periareolar, inframammary, transaxillary, or less commonly transumbilical. The transaxillary approach requires special consideration because of possible injury to the intercostobrachial nerve in the axilla, which may result in acute and chronic axillary pain.\(^{48}\) The implant is generally placed in 1 of 2 pockets—behind the breast parenchyma and superficial to the PM muscle, or deep to the PM muscle. As with tissue expanders, creation of a pocket posterior to the PM muscle can be a source of postoperative myofascial pain. The dissection required for the pocket involves disruption of the PM muscle and its attachments to the cartilaginous portion of the ribs. In some cases, the muscle fibers of the PM are split to access the plane posterior to the PM and anterior to the PM muscle. Unlike tissue expander placement, the implant will usually be placed at its final size and not inflated over time. In addition to direct manipulation and disruption to the muscles and fascia, the stretch of the PM muscle after implant placement can be substantial. The major source of pain from submuscular breast augmentation is myofascial and is transmitted by the pectoral nerves. Postoperative pain from the stretching and disruption of the pectoral muscles is common, and many surgeons prescribe muscle relaxants to ameliorate it.\(^{49}\)

Creation of the submuscular pocket may also directly disrupt the pectoral nerves and/or the lateral cutaneous branches of the intercostal nerves. As with breast cancer surgery, breast augmentation procedures can lead to persistent pain. In one study, 9.5% of patients reported moderate to severe persistent pain after submuscular breast augmentation, 75% reported sensory changes over the breast, and 38% met criteria for neuropathic pain.\(^{50}\)

**Other Cosmetic Breast Surgeries**

Two additional procedures to be considered are reduction mammoplasty and mastopexy. In these procedures, a volume of breast tissue is removed, while the areola and nipple are spared. From a perioperative analgesic standpoint, these procedures are similar to a simple mastectomy because only cutaneous and subcutaneous breast tissue is involved, and the pectoral muscles are not disrupted. The incisions vary but typically involve the periareolar region and inferior pole of the breast.

The various surgical procedures and the relevant innervation are summarized in Figure 8.

**Anatomic Basis of Analgesic Procedures**

The goals of perioperative analgesia are to provide or supplement operative anesthesia, reduce immediate postoperative pain, and reduce the incidence of chronic pain. Regional anesthesia modalities have gained popularity for breast surgery due to the recent focus on reducing the requirement for inpatient surgery, inpatient length of stay, and the incidence of persistent postsurgical pain. We now discuss the anatomic basis of various procedures for the control of perioperative breast pain, as summarized in Figure 8. A discussion of how to perform the various blocks is beyond the scope of this review.

**Intercostal Nerve Blocks**

Local anesthetic can be deposited near intercostal nerves to provide a band of anesthesia targeted to a specific dermatomal area. Multiple intercostal nerves must be blocked to achieve coverage for breast surgery, depending on the tissue disrupted (eg, T2–T7). Classically, 3 to 5 mL of local anesthetic solution is injected at each thoracic level.\(^{52}\) If only the medial breast is involved, intercostal blocks may be performed at any point along the intercostal nerve course, including at the exit point of the ACB just medial to the sternum. If the lateral breast is involved, intercostal blocks must be performed proximal to the origin of the lateral cutaneous branches of the intercostal nerves at the midaxillary line. Intercostal blocks should be combined with other approaches if the surgery involves myofascial pain, as thoracic intercostal blocks do not anesthetize nerves derived from the brachial or cervical plexuses.

**Thoracic Epidural**

The most common levels for placement of epidural injections or catheters for breast analgesia is T3–5. Similar to intercostal blocks, thoracic epidural anesthesia (TEA) without cervical spread would not block the branches of the brachial or cervical plexus that may contribute to perioperative breast surgery pain.

**Paravertebral Block**

The paravertebral space can be accessed to block the thoracic spinal nerves as they exit the intervertebral foramina. Local anesthetic deposited in this space can spread multiple levels superior to
and/or inferior, as well as into the intercostal space laterally, the contralateral paravertebral space, and the epidural space medially. This technique generally results in ipsilateral blockade of somatic and sympathetic nerves and can serve as the sole anesthetic for breast surgery, as long as blockade of the supraclavicular nerves, and/or the intercostal nerves other than the intercostobrachial nerve, is not expected to provide axillary analgesia, because sensory innervation to the breast and axilla is derived primarily from the intercostobrachial nerve and axilla. Bigeleisen and Wilson demonstrated 77% and 87% incidence of intercostobrachial nerve block with 10 mL volume infraclavicular block via a medial and lateral approach, respectively. Although anatomically possible, the extent to which infraclavicular block provides local anesthetic spread along the chest wall to anesthetize the lateral cutaneous branches of the intercostal nerves other than the intercostobrachial nerve, and thus provide breast analgesia, has not been adequately studied. With the possible exception of infraclavicular blocks, brachial plexus blocks alone will not anesthetize the thoracic intercostal nerves supplying the breast and would not be sufficient for complete breast analgesia.

**Pecs I block.** Novel blocks have recently been introduced in an effort to anesthetize key nerves derived from the brachial plexus, avoid blocking the brachial plexus nerves that innervate the arm, and block the cutaneous branches of the intercostal nerves. Blanco was the first to describe a novel ultrasound-guided interfascial plane block, the Pecs I block, targeting the LPN and MPN via an injection between the PM and Pm muscles (eg, 0.25% bupivacaine 0.4 mL/kg). Distribution of local anesthetic in this plane is expected to anesthetize the LPN as it courses anteriorly through or at the lateral margin of the Pm muscle, with the goal of reducing postoperative muscle spasm and myofascial pain from the pectoralis muscles (eg, surgeries involving the pectoral muscles, including tissue expander and subpectoral prostheses placement). Note that evidence is needed to support this theoretical mechanism of chest wall analgesia (see part II).

**Pecs II block.** In order to expand the utility of interfascial peripheral nerve blocks for breast surgery, Blanco et al proposed a modification of the Pecs I block, called the Pecs II block. This block is performed with ultrasound guidance at the level of ribs and/or subcutaneous tissue. The Pecs II block is performed with ultrasound guidance at the level of ribs and/or subcutaneous tissue. The Pecs II block is performed with ultrasound guidance at the level of ribs and/or subcutaneous tissue.
Pecs II block consists of 2 injections, one deep injection between the Pm muscle and the SAM with 20 mL bupivacaine 0.25% and one superficial injection identical to the Pecs I block (between the PM and Pm muscles) with 10 mL bupivacaine 0.25%. Both injections can be made via one skin puncture site and often via 1 needle pass. The terminology of this block (named the Pecs II block or modified Pecs I block by Blanco) has led to some confusion as some authors have erroneously used “Pecs II” to describe the deep injection alone.

The addition of the deep injection (between the Pm muscle and the SAM) targets 3 distinct nerve groups: the anterior divisions of the lateral cutaneous branches of the intercostal nerves that pierce the external intercostal muscle and SAM at approximately the midaxillary line, the LTN that courses along the superficial surface of the SAM, and the TDN that courses along the anterior division of the lateral cutaneous branches of the intercostal nerves, thus failing to provide complete analgesia for many surgical procedures.

Four studies utilizing continuous postoperative epidural infusion, 2 studies9,72 utilized epidural anesthesia in the operating room only, and 1 study6 utilized epidural morphine alone (Table 2). Three studies69,70,72 demonstrated effective surgical anesthesia with epidural block for modified radical mastectomy or mastectomy. All 5 studies demonstrated analgesic benefit with an epidural technique, although only 2 utilized a double-blind design. In the studies utilizing continuous postoperative epidural infusion, analgesic benefit persisted until epidural discontinuation (second postoperative day).71,72 In addition to reductions in pain scores and analgesic consumption, epidural anesthesia resulted in shorter hospital stay,71 faster achievement of postanesthesia care unit discharge readiness,72 and improved patient satisfaction.69,70,72

Although the evidence supports the ability of epidural technique to provide both surgical anesthesia and postoperative analgesia, concerns regarding adverse events and logistic constraints have prevented this technique from becoming common practice for breast surgery.

Intercostal Nerve Blocks

Five studies evaluating intercostal nerve block with a median Jadad score of 2 (range, 2–3) were included in the review. Of these 5 studies, 3 demonstrated improved analgesia in patients receiving intercostal blocks (Table 1).54–66 The role of intercostal nerve blocks in contemporary practice is questionable, given the mixed results, the risks associated with these multilevel blocks, and the presence of alternative peripheral approaches including local anesthetic infiltration and the novel interfascial peripheral nerve blocks. High-quality studies to directly compare intercostal nerve blocks to these alternative techniques, with attention to both analgesic benefit and adverse effects, are needed to clarify the utility of intercostal blocks for patients undergoing breast surgery.

Epidural Administration

Five studies evaluating TEA with a median Jadad score of 3 were included in the review. Of these 5 studies, 2 studies71,72 utilized continuous postoperative local anesthetic infusion, 2 studies69,70 utilized epidural anesthesia in the operating room only, and 1 study6 utilized epidural morphine alone (Table 2). Three studies69,70,72 demonstrated effective surgical anesthesia with epidural block for modified radical mastectomy or mastectomy. All 5 studies demonstrated analgesic benefit with an epidural technique, although only 2 utilized a double-blind design. In the studies utilizing continuous postoperative epidural infusion, analgesic benefit persisted until epidural discontinuation (second postoperative day).71,72 In addition to reductions in pain scores and analgesic consumption, epidural anesthesia resulted in shorter hospital stay,71 faster achievement of postanesthesia care unit discharge readiness,72 and improved patient satisfaction.69,70,72

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<th>Reference</th>
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<td>1991</td>
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<td>Lumpectomy</td>
<td>T3–T7, preop, blind, surgical block with lidocaine 2% (plus epinephrine or omipressin) 5 mL per level, intraop sedation (no GA)</td>
<td>GA</td>
<td>Need for postop analgesic medication‡</td>
<td>Less analgesic medication usage in block group</td>
<td>Less PONV in LA group</td>
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<td>1994</td>
<td>36/12</td>
<td>2</td>
<td>Lumpectomy</td>
<td>T3–T6, preop, blind, surgical block with lidocaine 1.5% plus epi, lidocaine 2% plus epi, or bupivacaine 0.5%, 4 mL per level, intraop sedation (no GA)</td>
<td>GA</td>
<td>Pain VAS every 10 min for first 90 min; analgesic consumption in first 24 h‡</td>
<td>Lower pain scores during first 90 min, less analgesic consumption in first 24 h in block group</td>
<td>Longer analgesic effect with bupivacaine</td>
</tr>
<tr>
<td>Fassoulaki et al</td>
<td>2001</td>
<td>47/49</td>
<td>3</td>
<td>Modified radical mastectomy, lumpectomy with ALND</td>
<td>T3–T5, intraop, blind, ropivacaine 1% 2 mL per level plus 12 mL brachial plexus infiltration (18 mL total)</td>
<td>Saline infiltration</td>
<td>Pain VAS at 0, 3, 6, 9, 24 h, PO analgesic consumption at 1, 3, 6 h; postop narcotic consumption at 1, 3, 6 h</td>
<td>No difference in pain scores or postop narcotic consumption</td>
<td>No difference in pain at 3 mo</td>
</tr>
<tr>
<td>Hidalgo and Pusic</td>
<td>2005</td>
<td>50/50</td>
<td>3</td>
<td>Augmentation (subpectoral; transaxillary, periareolar, or inframammary)</td>
<td>T2–T6, bilateral, preop, postinduction, bupivacaine 0.25% 40 mL total</td>
<td>No block</td>
<td>Pain VAS at 1, 3, 6, 24, 48, 72 h; postop narcotic consumption at 1, 3, 6 h</td>
<td>No difference in pain scores between PM infiltration and contralateral PM muscle infiltration with bupivacaine 0.25% with epi</td>
<td>No difference in pain scores between PM infiltration and placebo injection in second cohort of 15 patients</td>
</tr>
<tr>
<td>Nasr et al</td>
<td>2015</td>
<td>13/13</td>
<td>2</td>
<td>Augmentation (subpectoral, periareolar)</td>
<td>T2–T7, unilateral, preop, bupivacaine 0.25% with epi 3 mL per level, plus PM infiltration with bupivacaine 0.25% 2 mL</td>
<td>Contralateral intraop PM muscle infiltration with bupivacaine 0.25% with epi</td>
<td>Pain VAS at 0, 1, 3, 8, 24 h at rest and movement</td>
<td>No difference in pain scores between intercostal blocks and PM infiltration</td>
<td>No difference in pain scores between PM infiltration and placebo injection in second cohort of 15 patients</td>
</tr>
</tbody>
</table>

*Number of patients (active/control).
†Primary outcome(s) identified by bold font.
‡Primary outcome not defined.

ALND indicates axillary lymph node dissection; epi, epinephrine; GA, general anesthesia; intraop, intraoperative; IM, intramuscular; IV, intravenous; LA, local anesthetic; PACU, postanesthesia care unit; PO, per os; POD, postoperative day; PONV, postoperative nausea and vomiting; postop, postoperative; preop, preoperative; T, thoracic vertebral level; VAS, visual analog scale.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Year</th>
<th>n*</th>
<th>Jadad Score</th>
<th>Type of Surgery</th>
<th>Details of Intervention</th>
<th>Control</th>
<th>Relevant Outcomes†</th>
<th>Acute Analgesia Results</th>
<th>Other Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Opioid only</strong></td>
<td></td>
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<tr>
<td>Aida et al68</td>
<td>1999</td>
<td>14/15</td>
<td>4</td>
<td>Radical mastectomy</td>
<td>T3–T4, preop, morphine only (no LA) 0.06 mg/kg preop bolus and 0.02 mg/kg/h intraop infusion</td>
<td>Epidural saline</td>
<td>Pain VAS and postop morphine consumption (via PCEA) at 6, 12, 24, 48 h‡</td>
<td>Lower pain scores, less morphine consumption at all time points in preemptive epidural morphine group</td>
<td></td>
</tr>
<tr>
<td><strong>Local anesthetic—intraoperative only</strong></td>
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<tr>
<td>Yeh et al69</td>
<td>1999</td>
<td>32/32</td>
<td>2</td>
<td>Modified radical mastectomy</td>
<td>T5–6 or T6–7, preop, surgical block with lidocaine 2% to maintain C5–T6 level (no GA)</td>
<td>GA</td>
<td>Pain VAS at time of first analgesic, pethidine consumption at POD 2‡</td>
<td>Lower worst pain scores, less analgesic consumption, longer time to first analgesic in epidural group</td>
<td>Higher satisfaction, less adverse effects (PONV, dizziness, headache), lower cost in epidural group</td>
</tr>
<tr>
<td>Sundararathi et al70</td>
<td>2005</td>
<td>25/25</td>
<td>3</td>
<td>Modified radical mastectomy with ALND</td>
<td>T4–5, preop, surgical block with ropivacaine 0.2% 10- to 15-mL bolus, intraop infusion of ropivacaine 0.2% 5–10 mL/h, epidural morphine 1.5 mg bolus and epidural discontinued at end of surgery; interscalene brachial plexus block, preop, ropivacaine 0.2% 8-mL bolus; intraoperative sedation (no GA)</td>
<td>GA with postop scheduled IV opioids</td>
<td>Pain NRS in PACU, 12, 24 h postop; postop rescue analgesic consumption in PACU and ward‡</td>
<td>Lower pain scores in PACU and 12 h postop, less rescue analgesic consumption in epidural group</td>
<td>No difference in PONV; higher patient satisfaction scores in epidural group</td>
</tr>
<tr>
<td><strong>Local anesthetic—continuous postoperative infusion</strong></td>
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<tr>
<td>Correll et al71</td>
<td>2001</td>
<td>9/9</td>
<td>3</td>
<td>Unilateral mastectomy with TRAM flap reconstruction</td>
<td>T8–T10, preop, 2 mg morphine bolus postop, intraop and postop infusion of ropivacaine 0.15% and morphine 0.05 mg/mL at 8 mL/h, discontinued POD 2</td>
<td>No epidural</td>
<td>Pain VAS at 6 time points from POD 1–4; length of stay</td>
<td>Lower pain scores at 3 of 6 time points (on POD 1–2), shorter hospital stay in epidural group</td>
<td>No difference in ambulation time, oral intake time, PONV, pruritus, constipation</td>
</tr>
<tr>
<td>Doss et al72</td>
<td>2001</td>
<td>30/30</td>
<td>5</td>
<td>Modified radical mastectomy</td>
<td>T6–7, preop, surgical block with ropivacaine 0.2% 5- to 10-mL bolus (plus 3- to 5-mL boluses as needed intraop, no GA), postop infusion of ropivacaine 0.2% 3–6 mL/h, discontinued 48 h postop</td>
<td>GA with postop scheduled IV opioids</td>
<td>Pain VRS at POD 0–3; time to PACU discharge readiness‡</td>
<td>Lower pain scores at POD 0–2, faster PACU discharge readiness in epidural group</td>
<td>Higher incidence of PONV in control group; higher patient satisfaction scores in epidural group</td>
</tr>
</tbody>
</table>

*Number of patients (active/control).
†Primary outcome(s) identified by bold font.
‡Primary outcome not defined.

ALND indicates axillary lymph node dissection; epi, epinephrine; GA, general anesthesia; intraop, intraoperative; IV, intravenous; LA, local anesthetic; LND, lymph node dissection; NRS, numeric rating scale; PACU, postanesthesia care unit; PCEA, patient-controlled epidural analgesia; POD, postoperative day; PONV, postoperative nausea and vomiting; postop, postoperative; preop, preoperative; T, thoracic vertebral level; TRAM, transverse rectus abdominis myocutaneous; VAS, visual analog scale.
<table>
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<tr>
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<tr>
<td>Single-level injection</td>
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<tr>
<td>Pusch et al73</td>
<td>1999</td>
<td>44/42</td>
<td>2</td>
<td>Lumpectomy, mastectomy, with or without ALND</td>
<td>T4 injection, preop, Loss of Resistance technique, bupivacaine 0.5% 0.3 mL/kg; intraop sedation (no GA)</td>
<td>GA</td>
<td>Pain VAS hourly from 2–12 h; postop opioid and non-opioid analgesic consumption‡</td>
<td>Lower pain scores at all time points, less analgesic consumption in block group</td>
<td>Lower incidence of vomiting in block group</td>
</tr>
<tr>
<td>Terheggen et al74</td>
<td>2002</td>
<td>15/15</td>
<td>3</td>
<td>Lumpectomy, quadrantectomy with or without SLND, wire guided biopsy</td>
<td>T4 catheter, preop, LOR technique, surgical block with bupivacaine 0.5% 15–20 mL plus epi (preceded by mepivacaine 2% 15–20 mL for patients undergoing preop radiographic wire localization); intraop sedation (no GA); discontinued at end of surgery</td>
<td>GA with propofol</td>
<td>Pain VAS at 15, 30, 60, 90, 120 min and discharge</td>
<td>Lower pain scores at 15–90 min and discharge in block group</td>
<td>No difference in recovery time, low incidence of PONV in both groups</td>
</tr>
<tr>
<td>Kairaluoma et al75,76</td>
<td>2004, 2006</td>
<td>30/30</td>
<td>4</td>
<td>Mastectomy or tumorectomy with SLND</td>
<td>T3 injection, preop, LOR technique, bupivacaine 0.5% 0.3 mL/kg bolus</td>
<td>Sham block with subcutaneous saline injection</td>
<td>Pain VAS and NRS at rest and movement every 30 min for 2 h; PACU oxycodone consumption</td>
<td>Lower pain scores at all time points, less PACU opioid consumption in LA group</td>
<td>Less PONV and sedation in PACU. Lower pain intensity with movement at 1 mo, lower incidence of pain symptoms at 6 mo, lower incidence and intensity of pain at rest and movement at 12 mo in LA group</td>
</tr>
<tr>
<td>Hura et al77</td>
<td>2006</td>
<td>35/35</td>
<td>3</td>
<td>Modified radical mastectomy with ALND</td>
<td>T4 injection, preop, LOR technique, surgical block with ropivacaine 0.5% 0.4 mL/kg; intraop sedation (no GA)</td>
<td>Same block technique, surgical block with ropivacaine 0.5% 0.4 mL/kg; intraop sedation (no GA)</td>
<td>Pain NRS at 0, 0.5, 1, 2, 24 h; postop analgesic consumption at 24 h; sensory block onset</td>
<td>No difference in pain scores or analgesic consumption. Faster sensory block onset in ropivacaine group</td>
<td>Increased sensory block at 24 h in ropivacaine group</td>
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<thead>
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</thead>
<tbody>
<tr>
<td>Sidiropoulou et al78</td>
<td>2008</td>
<td>24/24</td>
<td>3</td>
<td>Modified radical mastectomy with ALND</td>
<td>T3 injection, preop, LOR technique, ropivacaine 0.5% 0.5% 20 mL, infusion with ropivacaine 0.5% 2 mL/h per catheter</td>
<td>Prior to closure, 2 wound catheters placed (one overlying PM, one in axilla), infusion with ropivacaine 0.5% 2 mL/h per catheter</td>
<td>Pain VAS every 4 h until 24 h; morphine consumption at 24 h</td>
<td>Lower pain scores at 4 h, but higher pain scores at 16 and 24 h in paravertebral group; no difference in opioid consumption</td>
<td>Less PONV in paravertebral group</td>
</tr>
<tr>
<td>Arunakul and Ruksa79</td>
<td>2010</td>
<td>10/10</td>
<td>2</td>
<td>Modified radical mastectomy</td>
<td>T4 injection, preop, LOR technique, bupivacaine 0.5% 0.5% 0.3 mL/kg</td>
<td>No block</td>
<td>Pain NRS at rest and movement at 1 and 24 h; intraop opioid consumption; postop morphine consumption at 24 h</td>
<td>Lower pain scores at 1 h, less intraop and postop opioid consumption in block group</td>
<td>No difference in PONV</td>
</tr>
<tr>
<td>Gardiner et al80</td>
<td>2012</td>
<td>20/20</td>
<td>3</td>
<td>Augmentation (subpectoral)</td>
<td>T4 injection, bilateral, preop, LOR technique, ropivacaine 3 mg/kg plus epi in 40 mL total bolus; preop surgical field infiltration with saline; intraop sedation</td>
<td>Preop surgical field infiltration with ropivacaine; intraop sedation</td>
<td>Pain VAS and oral dextropropoxyphene requirement every 4 h POD 0–3‡</td>
<td>Lower postdischarge pain scores, less recovery room opioid consumption in paravertebral group</td>
<td>Improved intraop cooperation and reduced intraop sedation requirement in paravertebral group</td>
</tr>
<tr>
<td>Bhuvaneswari et al81</td>
<td>2012</td>
<td>36/12</td>
<td>5</td>
<td>Total mastectomy with ALND</td>
<td>T3 injection, preop, LOR technique, bolus with 0.3 mL/kg of either bupivacaine 0.25% plus epi (12 patients), bupivacaine 0.5% plus epi (12 patients), or bupivacaine 0.25% plus fentanyl 2 μg/mL</td>
<td>Saline paravertebral injection</td>
<td>Cumulative 24 h pain NRS at rest and movement; postop rescue analgesic consumption at 24 h; time to first rescue analgesic</td>
<td>Lower cumulative pain scores at rest and movement, less rescue analgesic consumption, longer time to first rescue analgesic in patients receiving bupivacaine 0.5% or bupivacaine 0.25% plus fentanyl. No difference in patients receiving bupivacaine 0.25% alone</td>
<td></td>
</tr>
<tr>
<td>Hassan and Mahran82</td>
<td>2015</td>
<td>45/45</td>
<td>5</td>
<td>Modified radical mastectomy</td>
<td>Preop, ultrasound guided, bupivacaine 0.25% 0.3 mL/kg plus magnesium sulphate 100 mg</td>
<td>Same block technique, bupivacaine 0.25% 0.3 mL/kg alone</td>
<td>Pain VAS at rest and movement at 0.5, 2, 4, 6, 12, 24 h; time to first analgesic request, morphine consumption at 24 h</td>
<td>Lower pain scores at all time points, longer time to first analgesic request, less morphine consumption in magnesium group</td>
<td></td>
</tr>
</tbody>
</table>
### Multilevel Injection

**Klein et al.** 2000 30/30 3

**Unilateral or bilateral augmentation, reconstruction**

| T1–T7 injections, preop, unilateral or bilateral, blind, surgical block with bupivacaine 0.5% plus epi 4-mL bolus per level; intraop sedation (no GA) | GA | Pain VAS and NRS at 0.5, 1, 24, 48, 72 h‡ | Lower pain scores at 0.5, 1, and 24 h in block group | Less severe nausea at 24 h |

**Naja et al.** 2003 30/30 3

**Partial mastectomy, simple mastectomy, modified radical mastectomy**

| T1–T5 injections (3–5 injections depending on surgery type), preop, nerve stimulator guided, 3–5-mL bolus per level of a lidocaine 1.2% and bupivacaine 0.125% mixture containing epi, fentanyl 2.5 μg/mL and clonidine 15 μg/mL; intraop sedation (no GA) | GA | Pain VAS at rest and movement at 6, 12, 24, 36 h, POD 2–5; supplemental opioid requirement at 72 h | Lower pain scores with movement at all time points, lower pain scores at rest at all time points from POD 0–3, less supplemental opioid requirement at all time points until 72 h in block group | Less PONV and shorter hospital stay in block group |

**Moller et al.** 2007 38/41 5

**Tumorectomy or mastectomy with SLND**

| C7–T5 injections, preop, blind, ropivacaine 0.5% 5-mL bolus per level (30 mL total) | Saline paravertebral injection | Pain NRS at 0, 0.5, 1, 1.5, 2 h, PACU discharge, POD 0–2; intraop and postop fentanyl consumption | Lower pain scores in the PACU only, less intraop and PACU opioid consumption in LA group. No differences after PACU discharge | No difference in PONV |

**Boughey et al.** 2009 39/41 2

**Partial mastectomy with SLND/ALND, mastectomy with or without SLND/ALND**

| T1–T6 injections, preop, LOR technique, ropivacaine 0.5%–1% plus epi, 3–6 mL per level | No block | Pain NRS and pain-free proportion at 0, 1, 3, 6 and 24 h; postop analgesic consumption | Lower pain scores and pain-free proportion at 1 and 3 h in block group, higher pain scores at POD 1 in block group; no difference in postop analgesic consumption | No difference in PONV or time to discharge |

**Omar et al.** 2011 21/19/20 5

**Modified radical mastectomy**

| T1 and T4 injection, LOR technique, bupivacaine 0.5% 2 mg/kg plus ketamine 0.5 mg/kg (21 patients) or tramadol 1.5 mg/kg (19 patients) | Same block technique, bupivacaine 0.5% 2 mg/kg alone | Fentanyl consumption in PACU and at 24 h, pain VAS at 0, 1 h, PACU discharge, and 4, 8, 12, 18, 24 h | No differences in opioid consumption or pain scores | No difference in opioid consumption or pain scores |

**Das et al.** 2012 29/30 3

**Lumpectomy**

| T3–6 injections, preop, LOR technique, surgical block with bupivacaine 0.5% 5-mL bolus per level; intraop sedation (no GA) | GA | Pain VAS at 0, 2, 4, 6, 12, 24 h; rescue analgesic consumption at 24 h; time to first rescue analgesic | Lower pain scores at 0, 2, 4 h, lower rescue analgesic consumption, longer time to first rescue analgesic in block group | Higher patient satisfaction scores in block group |

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<th>Other Results</th>
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<tbody>
<tr>
<td>Naja et al</td>
<td>2013</td>
<td>28/26</td>
<td>5</td>
<td>Partial mastectomy, simple mastectomy, modified radical mastectomy with ALND</td>
<td>T1–T5 injections (3–5 injections depending on surgery type), preop, nerve stimulator guided, surgical block with 0.06 mL/kg bolus per level of a lidocaine 1.25% and bupivacaine 0.175% mixture containing epi and clonidine 3.75 μg/mL; intraop sedation (no GA)</td>
<td>Same block technique and LA bolus without the addition of clonidine; intraop sedation (no GA)</td>
<td>Pain VAS and postop analgesic consumption at 6, 12, 24, 48, 72 h, 1 and 2 wk</td>
<td>Lower pain scores at rest and movement at 24, 48 and 72 h, less postop analgesic consumption at 48 h in clonidine group</td>
<td>Shorter time to resume daily activity in clonidine group</td>
</tr>
<tr>
<td>Abdallah et al</td>
<td>2014</td>
<td>33/31</td>
<td>5</td>
<td>Partial mastectomy, mastectomy with and without SLND or ALND, mastectomy with implant insertion</td>
<td>T1–T5 injections, preop, ultrasound-guided, parasagittal approach, ropivacaine 0.5% 5 mL per level, GA with propofol-based Total Intravenous Anesthesia</td>
<td>Sham subcutaneous injection, GA with sevoflurane</td>
<td>Ambulatory quality of recovery score; pain VAS on POD 0, 2, 4, 7, intraop and postop morphine consumption</td>
<td>Higher quality of recovery scores at discharge and POD 2, lower pain scores on POD 0 and 2, less intraop and PACU opioid consumption in block group</td>
<td>Lower incidence of PONV, shorter time to discharge in block group</td>
</tr>
<tr>
<td>Mohamed et al</td>
<td>2014</td>
<td>30/30</td>
<td>5</td>
<td>Modified radical mastectomy with ALND</td>
<td>T1–T6 injections, preop, blind, bupivacaine 0.25% plus 1 μg/kg dexmedetomidine 3–4 mL per level</td>
<td>Same block technique, bolus with bupivacaine 0.25% alone</td>
<td>Pain VAS at 2, 4, 6, 12, 24, 36, 48 h; rescue analgesic consumption 48 h; time to first analgesic request‡</td>
<td>No difference in pain scores, but less rescue analgesic consumption and longer time to first analgesic request in dexmedetomidine group</td>
<td>Lower incidence of PONV in paravertebral group</td>
</tr>
<tr>
<td>Fallatah and Mousa</td>
<td>2016</td>
<td>20/20</td>
<td>3</td>
<td>Lumpectomy with ALND</td>
<td>T2–T6 injections, preop, blind, bupivacaine 0.5% 4 mL per level</td>
<td>Postop morphine PCA</td>
<td>Pain NRS at 1, 6, 12, 24 h, time to first analgesic request, morphine consumption at 24 h</td>
<td>Lower pain scores at 6 and 12 h, longer time to first analgesic request, less morphine consumption in paravertebral group</td>
<td>Lower incidence of PONV in paravertebral group</td>
</tr>
<tr>
<td>Wolf et al</td>
<td>2016</td>
<td>35/39</td>
<td>2</td>
<td>Reconstructive prosthetic breast surgery</td>
<td>T1–T6 injections, preop, LOR technique, ropivacaine 0.5%–1% 3–6 mL per level</td>
<td>No block</td>
<td>Pain NRS at 0, 0–1, 1–3, 3–6, 18–22, 1 wk; intraop fentanyl consumption‡</td>
<td>Lower pain scores at 0–1, 1–3, 3–6 h, less intraop opioid consumption in block group</td>
<td>Lower incidence of PONV in paravertebral group</td>
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<tr>
<td>Continuous infusion</td>
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<tr>
<td>Buggy and Kerin</td>
<td>2004</td>
<td>10/10</td>
<td>3</td>
<td>Mastectomy with LDMF</td>
<td>T3 or T4 catheter, preop, LOR technique, levobupivacaine 0.25% 10–15 mL bolus, infusion with levobupivacaine 0.25% 8–10 mL/h; discontinued at ≥24 h</td>
<td>No block, IV morphine</td>
<td>Pain VAS at rest and movement hourly until 20 h</td>
<td>Lower pain scores at rest and movement in block group</td>
<td>Higher flap tissue oxygen tension in block group</td>
</tr>
</tbody>
</table>
Burlacu et al95 2006 38/14 2 Mastectomy with ALND with or without flap reconstruction, partial mastectomy with ALND

T3 catheter, preop, LOR technique, levobupivacaine 0.25% 20-mL bolus plus either saline (13 patients), fentanyl 150 μg (13 patients), or clonidine 150 μg (12 patients); postop infusion with levobupivacaine 0.1% (13 patients), levobupivacaine 0.05% plus fentanyl 14 μg/mL (13 patients), or levobupivacaine 0.05% plus clonidine 3 μg/mL (12 patients) at 5–15 mL/h; discontinued at 48–72 h; No block

Pain VAS at 2, 4, 8, 12, 24 h; postop morphine consumption at 24 h via IV PCA

Lower pain scores at 4 h in block group; lower pain scores at 24 h and less opioid consumption at 24 h in block patients receiving LA additives (fentanyl or clonidine)

Increased nausea and vomiting in fentanyl patients, increased hypotension in clonidine patients

Iohom et al99 2006 14/15 2 Mastectomy or tumorectomy with ALND

T3 catheter, preop, LOR technique, bupivacaine 0.25% 10-mL bolus; infusion with bupivacaine 0.25%; discontinued ≤48 h

Standard analgesia with as needed opioid and non-opioid analgesics

Pain VAS at rest and movement at 0.5, 2, 4, 8, 12 h, and POD 2–5

Lower pain scores with movement at 0.5, 2, 4, 8, 12 h, and POD 2–5

Lower incidence of pain at 2–3 mo in block group

McElwain et al96 2008 19/18 4 Mastectomy or wide local excision with and without ALND, with and without reconstruction

T2 or T3 catheter, preop, blind, levobupivacaine 0.25% 20-mL bolus pre-incision, 10 mL at wound closure; postop infusion with levobupivacaine 0.2% 8 mL/h, PCRA demand dose 3 mL every 15 min discontinued 548 h

Same catheter placement and levobupivacaine boluses and infusion; PCRA demand dose 8 mL every 30 min

Pain VAS at rest and movement every 4 h for 36 h; postop rescue analgesic requirements

No difference in pain scores or rescue analgesic requirement between groups

Buckenmaier et al97 2010 52/21 5 Lumpectomy with SLND/ALND, mastectomy, modified radical mastectomy

T3 catheter, preop, blind, surgical block with ropivacaine 0.5% 0.3 mL/kg with epi bolus, plus T1 and T6 injections with ropivacaine 1% with epi 5 mL each; intraop sedation (no GA); postop infusion with ropivacaine 0.1% (20 patients) or 0.2% (20 patients) at 10 mL/h; discontinued at 72 h

Same LA single injections and catheter placement, postop saline infusion

Pain scale at POD 1, 3, 5, 7; total inpatient and outpatient analgesic consumption

No difference in pain scores between groups (pain scores low in all groups); no difference in total analgesic consumption

Conversion to GA in 9 of 73 patients; no difference in nausea

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<th>Reference</th>
<th>Year</th>
<th>n*</th>
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<th>Acute Analgesia Results</th>
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<tr>
<td>Deegan et al98</td>
<td>2010</td>
<td>15/17</td>
<td>3</td>
<td>Partial mastectomy, mastectomy with ALND</td>
<td>T2 or T3 catheter, preop, LOR technique, levobupivacaine 0.25% 20-mL bolus; GA with propofol; postop infusion with levobupivacaine 0.25% 8–10 mL/h; discontinued at 48 h</td>
<td>No block, GA with sevoflurane and IV morphine</td>
<td>Pain VAS at 1, 2, 24 h; morphine consumption at 24 h</td>
<td>Lower pain scores at 1 and 2 h in block group. No difference at 24 h. Less morphine consumption in block group</td>
<td>No difference in the levels of the majority of serum cytokines studied</td>
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<tr>
<td>Abdelhalim99</td>
<td>2011</td>
<td>20/20</td>
<td>2</td>
<td>Partial mastectomy, modified radical mastectomy</td>
<td>T4 catheter, preop, LOR technique, lidocaine 2% 20-mL bolus, infusion with lidocaine 1% 5 mL/h with 5-mL boluses as needed</td>
<td>No block</td>
<td>Pain VAS at rest and movement at 30 min, 1, 2, 4, 12, 24 h, intraop fentanyl consumption and postop morphine consumption at 24 h</td>
<td>Lower pain scores, less intraop and postop opioid consumption in the block group, longer time to first analgesic request in block group</td>
<td>No difference in PONV</td>
</tr>
<tr>
<td>Ilfeld et al100</td>
<td>2014</td>
<td>30/30</td>
<td>5</td>
<td>Unilateral or bilateral mastectomy with or without ALND</td>
<td>T4 catheter, preop, unilateral or bilateral, ultrasound guided, parasagittal approach, ropivacaine 0.5% plus epi 15-mL bolus; infusion with ropivacaine 0.4% 5 mL/h; discontinued POD 3</td>
<td>Same catheter placement and ropivacaine bolus, saline infusion at 5 mL/h; discontinued POD 3</td>
<td>Brief Pain Inventory on POD 1, 4, 8, 28; opioid consumption on POD 0, 1, 4, 8</td>
<td>Lower pain inventory scores on POD 1, less opioid consumption only in the recovery room in LA infusion group</td>
<td>Lower pain inventory scores and less pain-induced dysfunction at 12 mo in LA infusion group</td>
</tr>
<tr>
<td>Karmakar et al101</td>
<td>2014</td>
<td>117/ 60</td>
<td>3</td>
<td>Modified radical mastectomy with ALND</td>
<td>T3 catheter, preop, LOR technique, ropivacaine 2 mg/kg plus epi in 20-mL bolus; infusion with saline (57 patients) or ropivacaine 0.25% 0.1 mL/kg/h (60 patients); discontinued at 72 h</td>
<td>No block</td>
<td>Pain NRS at rest and movement at 0, 2, 4, 6, 12, 18, 24, 36, 48, 72 h; analgesic consumption in PACU and ward</td>
<td>No difference in acute pain scores or postop analgesic consumption</td>
<td>No difference in incidence of chronic pain at 3 and 6 mo. Less severe chronic pain in block group</td>
</tr>
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</table>
Paravertebral Block

Thirty-one studies of PVB with a median Jadad score of 3 (range, 2–5) were included in the review. Of these, 10 studies used a single injection at 1 level, 11 studies utilized a single injection at multiple levels, and 10 studies utilized continuous infusions (Table 3). Single-level injections were performed at T2–T4, and multilevel injections were performed at 3 to 7 levels ranging from C7–T7. Twenty-three studies compared PVB to alternative analgesic approaches (ie, general anesthesia, intravenous opioids, local infiltration). All but 1 of these 24 studies identified analgesic benefit of PVB as indicated by pain scores, analgesic consumption, or time to first analgesic. It should be noted that only 4 of the 23 positive studies used a double-blind design.

The optimal dosing strategy with PVB for breast surgery (single injection, single injection with additives, or continuous infusion) remains unclear. The reported duration of analgesic benefit for patients with single-injection PVB varied between studies, with evidence of analgesia as late as postoperative day 3.

Additional outcomes were reported in several studies. Seven studies reported an improvement in postoperative nausea and vomiting, and 2 reported shortened length of hospital stay. In addition, 4 studies (only 2 of which were double-blind) demonstrated an improvement in pain incidence or characteristics at 1 to 12 postoperative months.

In summary, the literature supports PVB as an effective perioperative analgesic technique for breast surgery. Paravertebral block can also provide surgical anesthesia and may decrease nausea and vomiting, hospital stay, and chronic postsurgical pain. The use of paravertebral catheters has not reliably been demonstrated to be superior to a single-injection technique at 1 or multiple levels. Similar to epidurals, the safety of PVBs for outpatient surgery is a concern, given the trend toward outpatient performance of breast surgeries. Outpatient breast surgery with ambulatory paravertebral catheters has been described, but its analgesic benefit has not been demonstrated. Finally, further studies comparing PVB to local anesthetic infiltration are needed.

Brachial Plexus and Novel Peripheral Nerve Blocks

Brachial Plexus Blocks

One brachial plexus block study, with a Jadad score of 3, was included in the review (Table 4). Kaya et al demonstrated analgesic benefit of relatively large-volume (30 mL) interscalene block alone for modified radical mastectomy. In addition, Sundarathithi et al included an interscalene block as a supplement to TEA, but the study design prevents an assessment of the specific impact of the interscalene block (Table 2). In summary, although 1 study lends some support to the theoretical benefit of brachial plexus blocks, the undesirable upper-extremity block that results has prevented the incorporation of these approaches into clinical practice.

Interfascial Plane Blocks

No RCTs of Pecs I block were identified in our review. Four Pecs II block studies with a median Jadad score of 3 were included in our review. Bashandy and Abbas investigated Pecs II block versus no block for modified radical mastectomy in an observer-blinded study. They demonstrated reduced pain scores in the first 24 hours, reduced opioid consumption in the first 12 hours, less nausea and vomiting, less sedation, and shorter postanesthesia care unit and hospital stay in patients receiving Pecs II block. In an unblinded study, Wahba and Kamal compared Pecs II block to single-injection, 1-level T4 paravertebral for modified radical mastectomy under...
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<td><strong>Brachial plexus block</strong></td>
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<tr>
<td>Kaya et al104</td>
<td>2013</td>
<td>30/30</td>
<td>3</td>
<td>Modified radical</td>
<td>Interscalene brachial plexus block, postop, prior to</td>
<td>No block</td>
<td>Pain VAS at 0, 1, 2, 4, 6, 12, and 24 h; postop morphine consumption at 24 h</td>
<td>Lower pain scores at all time points from 0–12 h, less opioid consumption at 24 h in block group</td>
<td>Less PONV in block group</td>
</tr>
<tr>
<td>Wahba and Kamal105</td>
<td>2014</td>
<td>30/30</td>
<td>3</td>
<td>Modified radical</td>
<td>Pecs II, preop, ultrasound guided, levobupivacaine 0.25% 10 mL between PM and Pm muscles and 20 mL superficial to SAM at level of ribs 2–4</td>
<td>T4 single-injection PVB, preop, LOR technique, levobupivacaine 0.25% 15–20 mL</td>
<td>Pain NRS at rest and movement at 1, 6, 12, 18, 24 h; postop morphine consumption at 24 h; time to first analgesic request</td>
<td>Less opioid consumption at 24 h, longer time to first analgesic request, lower pain scores with movement at 1 h, lower pain scores at rest at 1, 6, 12 h in Pecs group. Higher pain scores at rest and movement at 18 and 24 h in Pecs group.</td>
<td>No difference in PONV</td>
</tr>
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<td>Bashandy and Abbas106</td>
<td>2015</td>
<td>60/60</td>
<td>3</td>
<td>Modified radical</td>
<td>Pecs II, preop, ultrasound guided, bupivacaine 0.25% 10 mL between PM and Pm muscles and 20 mL superficial to SAM at level of 3rd rib</td>
<td>No block</td>
<td>Pain VAS at 0, 3, 6, 9, 24 h; intraop fentanyl requirement postop morphine consumption at 0–4, 4–12, 12–24 h</td>
<td>Lower pain scores at all time points, less intraop opioid requirement, less opioid consumption at 0–12 h in block group</td>
<td>Lower PONV and sedation scores, shorter PACU and hospital stay in block group</td>
</tr>
<tr>
<td>Eldeen107</td>
<td>2016</td>
<td>20/20</td>
<td>2</td>
<td>Lumpectomy without</td>
<td>Pecs II, preop, ultrasound guided surgical block with bupivacaine 0.5% 10 mL plus 5 μg dexmedetomidine between PM and Pm muscles and 20 mL working on sensory to SAM at level of ribs 2–4</td>
<td>T5–6 spinal, preop, hyperbaric bupivacaine 0.5% 1 mL plus dexmedetomidine 5 μg</td>
<td>Ability of blocks to provide surgical anesthesia; pain VAS intraop and at 1, 2, 4, 8, 16, 24 h postop</td>
<td>All blocks provided adequate surgical anesthesia; lower pain scores at all time points in Pecs II group</td>
<td>Longer duration sensory (mean 16.6 h) and motor (mean 15.7 h) block in Pecs II group</td>
</tr>
<tr>
<td>Othman et al108</td>
<td>2016</td>
<td>30/30</td>
<td>4</td>
<td>Modified radical</td>
<td>Pecs II, postinduction, ultrasound guided, bupivacaine 0.25% 30 mL plus ketamine 1 mg/kg in divided doses between PM and Pm muscles (10 mL) and superficial to SAM (20 mL) at level of ribs 2–4</td>
<td>Same block technique and LA bolus without the addition of ketamine</td>
<td>Pain VAS at 0, 2, 4, 6, 12, 24, 48 h, time to first rescue analgesic request, morphine consumption at 48 h</td>
<td>No difference in pain scores; longer time to first rescue analgesic and less opioid consumption in ketamine group</td>
<td></td>
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</table>

*Number of patients (active/control).
†Primary outcome(s) identified by bold font.
ALND indicates axillary lymph node dissection; intraop, intraoperative; NRS, numeric rating scale; PACU, postanesthesia care unit; postop, postoperative; preop, preoperative; VAS, visual analog scale.
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<tr>
<td>Intercostal nerve block (Table 1)</td>
<td>• Multiple injections (3–6 levels), proximal to lateral cutaneous branch origin (angle of rib)</td>
<td>• No block of brachial plexus components</td>
<td>• Small body of evidence of analgesic benefit for lumpectomy and modified radical mastectomy</td>
<td>• Comparison with local anesthetic infiltration and interfascial plane blocks</td>
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<tr>
<td>Epidural block (Table 2)</td>
<td>• T3–4 to T6–7 level epidural analgesia or anesthesia</td>
<td>• Block of brachial plexus components only if cephalad spread</td>
<td>• Consistent evidence of analgesic benefit for mastectomy</td>
<td>• Continued benefit until catheter discontinuation</td>
</tr>
<tr>
<td>Paravertebral block (Table 3)</td>
<td>• Single-level injection or continuous infusion at T2–T4</td>
<td>• No block of brachial plexus components</td>
<td>• Consistent evidence of analgesic benefit for all common breast surgeries</td>
<td>• Comparison with local anesthetic infiltration and interfascial plane blocks</td>
</tr>
<tr>
<td>Interscalene brachial plexus block (Table 4)</td>
<td>• Interscalene approach alone has been studied in 1 RCT</td>
<td>• Block of LTN</td>
<td>• One RCT showing analgesic benefit for modified radical mastectomy</td>
<td>• Anticipate benefit only for procedures producing myofascial pain (eg, submuscular augmentation)</td>
</tr>
<tr>
<td>Pecs I block</td>
<td>• LA deposited between the PM and minor muscles</td>
<td>• Block of LPN and MPN</td>
<td>• No RCTs</td>
<td>• RCTs assessing magnitude of analgesic effect for subpectoral procedures</td>
</tr>
<tr>
<td>Pecs II block (Table 4)</td>
<td>• Combination of 2 LA depositions</td>
<td>• Block of LPN, MPN, LTN, and TDN, anterior divisions of the lateral cutaneous branches of the intercostal nerves (T2–4, occasionally to T6)</td>
<td>• 2 RCTs showing analgesic benefit for modified radical mastectomy</td>
<td>• Comparison with paravertebral and with local anesthetic infiltration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No block of ACBs of the intercostal nerves</td>
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TABLE 5. (Continued)

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</table>
| Serratus plane block   | • LA deposited deep to the latissimus dorsi muscle, either superficial or deep to the SAM, at level of rib 5 in the midaxillary line  
  • Alone or in combination with Pecs I block | • Block of LTN, TDN, anterior divisions of the lateral cutaneous branches of the intercostal nerves (T2-9)  
  • No block of LPN, MPN, or ACBs of the intercostal nerves | • No RCTs | • RCTs assessing analgesic benefit and comparing with other techniques  
  • Further comparison with deep injection of Pecs II block regarding distribution and duration |
| Blocks of the ACBs of the intercostal nerves | • PIFB: LA deposited between the PM and external intercostal muscles  
  • Transversus thoracic muscle plane block: LA deposited between the internal intercostal and transversus thoracis muscles | • No block of lateral cutaneous branches of the intercostal nerves  
  • No block of brachial plexus components | | • Evaluation of the reliability, analgesic impact, and necessity of these approaches |

LA indicates local anesthetic.

ACNOWLEDGMENTS

The authors thank Anna Getselman, executive director, Health Sciences Library, Columbia University Medical Center, for her significant contributions to the literature review.

REFERENCES


CONCLUSIONS

Acute pain following breast surgery is common, and numerous options exist for perioperative analgesia. An understanding of the anatomy of the breast and the anatomic structures disrupted by various surgical procedures will aid in selecting the appropriate anesthetic techniques and evaluating the analgesic benefits of each intervention. We summarize the anatomic considerations, surgical procedures, and analgesic procedures in Figure 8 and the evidence for each of the analgesic procedures in Table 5. Both epidural and PVBs have been shown to provide effective analgesia for breast surgery. Paravertebral block has consistently demonstrated enhanced analgesia while improving additional aspects of postoperative recovery, but further studies are needed to determine the safety and efficacy of alternative analgesic techniques.


