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REVIEW ARTICLE

Optimizing non-opioid pain control after implant-based breast reconstruction: a review of the literature and proposed pain control algorithm

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ABSTRACT

Despite the intense focus on the opioid epidemic and its known association with surgical procedures, there is a paucity of evidence-based literature on pain management in implant-based breast reconstruction (IBR). Herein, we present an updated review of the literature aimed at identifying pain treatment protocols to minimize narcotic use and its associated potential addiction in IBR. A comprehensive review of the published English literature was conducted using Ovid Medline/PubMed Database without timeframe limitations. The inclusion criteria of selected articles presented in this review included studies reporting objective outcomes of pain modulation (preoperatively, intraoperatively and postoperatively) in IBR. Articles for inclusion were stratified based on intervention. A total of 219 articles were identified in the initial search query, with 23 studies meeting the inclusion criteria. Pain optimization interventions in IBR are herein summarized and analyzed based on the reported outcomes of each respective study. There is a substantial need for evidence-based guidelines in the plastic surgery literature for pain optimization without the use of opioids. While this review of studies to date investigates potential solutions, we hope this area of study continues to be a top priority for plastic surgeons to allow for optimized post-operative care for patients following IBR.

Abbreviations: ERAS: enhanced recovery after surgery; IBR: implant-based breast reconstruction; PICO: problem, intervention, comparison, outcome; RCT: randomized controlled trial; ADM: acellular dermal matrix; NSAID: non-steroidal anti-inflammatory drug; LOE: level of evidence; TE: tissue expander; DTI: direct to implant; NMDA: N-methyl-D-aspartate; PVB: paravertebral block; LOS: length of stay; POD: postoperative day

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Introduction

The known association with post-operative narcotic use has led to a concomitant increase in the awareness and interest in optimizing pain control after surgery, including implant-based breast reconstruction [1]. Decreased postoperative narcotic requirements theoretically have the potential to substantially decrease the risk of opioid abuse and addiction [2]. Therefore, it behooves plastic surgeons and allied health professionals to optimize pain management and minimize narcotic needs for women undergoing breast reconstruction after surgical treatment for breast cancer. Multimodal analgesia pain management strategies with non-opioid analgesics have been shown to improve the value of surgical care in patients undergoing various operations across surgical specialties including gynecology, colorectal and general surgery. However, its application in reconstructive breast surgery has been relatively recent [2]. There are currently several articles that seek to minimize post-operative pain under the general moniker of an 'Enhanced Recovery After Surgery (ERAS)' protocol [1,3–7]. However, to our knowledge, there is no evidence-based protocol aimed at minimizing pain following implant-based breast reconstruction (IBR). To that end, we present a comprehensive review of the literature to identify published studies that have included patients who underwent specific non-opioid pain control protocols before, during, or after undergoing IBR, either as a comparative or observational cohort study. To minimize the use of systemic opioids and consequent risk for potential addiction in IBR, other strategies are needed. The primary aim of this study was to identify other pain control methods than systemic opioids and investigate the evidence of them. The secondary aim was to suggest an algorithm for optimizing pain control in IBR, based on the review.

Methods

Search strategy

Two authors (J.D.O. and R.W.K.) independently conducted the electronic searches using Ovid Medline/PubMed Database without timeframe limitations on 15 February 2019. Only English language articles were included. Disagreements were resolved by the senior author (J.R.G.). The following were used as keywords in all combinations in the search strategy: ((pain) AND implant) AND breast reconstruction), with full Medical Subject Headings (MeSH) combinations including ((‘pain’[MeSH Terms] OR ‘pain’[All Fields]) AND implant[All Fields]) AND (‘mammaplasty’[MeSH Terms] OR ‘mammaplasty’[All Fields] OR (‘breast’[All Fields] AND ‘reconstruction’[All Fields]) OR ‘breast reconstruction’[All Fields]). The compiled reference lists were compared and reviewed for potential relevance. The bibliographies of included studies were also searched for missed articles. See Figure 1 for a detailed

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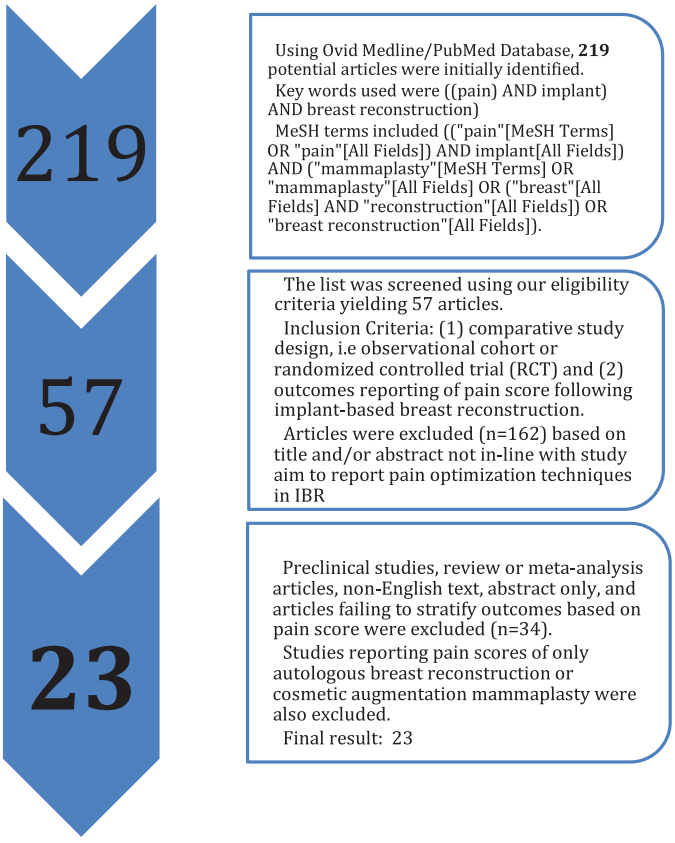

Figure 1. Flow chart of article identification and selection criteria following the PRISMA guidelines.

representation of the search strategy, including article identification, exclusion and ultimate selection.

Selection criteria and interventions

PICO

Problem/patient/population. The aim of this study was to identify published literature reporting pain management outcomes in patients who underwent breast reconstruction with an implant placed (either sub-muscular or sub-glandular).

Intervention/indicator. A variety of interventions have been reported in the current literature to mitigate postoperative pain following IBR; However, there is a paucity of evidence-based guidelines from national and international plastic surgery societies to guide the indicated interventions. We report below the range of interventions identified in the literature.

Comparison. As each of the included studies represent a heterogeneous profile of postoperative pain outcomes in patients undergoing IBR, our goal of comparison across interventions in this study was to outline the respective outcomes in detail while stating the concurrent limitations of each study individually. This will allow clinicians to review the spectrum of reported pain outcomes following the interventions analyzed in IBR patients to develop an evidence-based guide to effective and safe pain management.

Outcome. Measured outcomes, while unique to each study included given the heterogeneous and non-standardized array of outcomes data, attempted to quantify patient-reported pain scores following pain management interventions. While subjective and qualitative in nature, these outcomes measures are useful tools to identify potentially effective pain management interventions for the development of future societal guidelines.

Eligibility criteria included the following: (1) comparative study design, that is, observational cohort or randomized controlled trial (RCT) and (2) outcomes reporting of pain score following implant-based breast reconstruction. Preclinical studies, review or meta-analysis articles, non-English text, abstract only and articles failing to stratify outcomes based on pain scores were excluded. Studies reporting pain scores of only autologous breast reconstruction were also excluded. Outcomes of interest for analysis were identified, including pain management intervention type, the patient reported outcomes of pain scores, reconstruction type (pre-pectoral vs sub-pectoral implant placement), use of adjunctive tissue expanders and/or acellular dermal matrices, as well as the mode of analgesic and timing of pain intervention (preoperatively, intraoperatively or postoperatively).

Data extraction and processing

The extracted data included: year of study, study design, country, patient demographics, follow-up duration, pain intervention type and reported outcomes of pain scores when available. Articles for inclusion were stratified based on intervention analysis on pain after IBR, including sub-pectoral versus pre-pectoral implant placement, acellular dermal matrix (ADM) utilization, nerve block(s) performed preoperatively versus intraoperatively versus postoperatively, neural modulator or non-steroidal anti-inflammatory drug (NSAID) utilization. Data extraction from articles, tables and figures was performed by one reviewer (J.D.O) with the accuracy of data entry confirmed by two additional reviewers (R.W.K. and J.R.G.). Levels of evidence (LOE) were assigned to each of the included articles following the criteria described in the Newcastle Ottawa Scale.

Results

A total of 219 articles were identified utilizing the initial search query. After applying the inclusion and exclusion criteria, 57 articles underwent full-text review. The final screening of [8–17] reviewed articles yielded 23 studies for final inclusion (see Figure 1) [10,18–39]

Overall, studies included reported IBR with a specific focus on pain optimization with the following interventions: nerve block (1 preoperative, 7 intraoperative), postoperative ketorolac (1), postoperative ibuprofen (1), bupivacaine pump (2), simultaneous lipofilling at time of implant placement (1), ERAS protocol (1), ADM + prepectoral implant placement (6) and tissue expander (3).

Pre-operative, intra-operative and post-operative nerve blocks

While the vast majority of these studies reported a positive effect observed in the quality of recovery with the implementation of nerve blocks either intraoperatively or preoperatively, one study published in 2018 by Lanier et al. [18] failed to identify the same association; Upon analyzing the efficacy of intraoperative nerve blocks, the authors did not find convincing data to suggest an effect on the overall quality of life following IBR [18]. In their study, a prospective, double-blinded, placebo RCT was conducted in which 47 patients undergoing immediate TE/implant breast reconstruction were randomized to either (1) intraoperative intercostal and pectoral nerve blocks with 0.25% bupivacaine with

Table 1. Nerve blocks in IBR.

First author and year	Title	Level of evidence	Intervention	Outcomes/results
Lanier 2018	Intraoperative Nerve Blocks Fail to Improve Quality of Recovery after Tissue Expander Breast Reconstruction: A Prospective, Double-Blinded, Randomized, Placebo-Controlled Clinical Trial	I	Intraoperative bupivacaine, ephinephrine intercostal or pectoral nerve block	No effect on overall quality of recovery from tissue expander/implant breast reconstruction
Motakef 2017	Liposomal Bupivacaine in Implant-Based Breast Reconstruction	I	Liposomal bupivacaine in breast pocket	Liposomal bupivacaine reduces opioid and benzodiazepine consumption, length of stay and hospital charges
Vemula 2013	The Use of Intercostal Nerve Blocks for Implant-Based Breast Surgery	II	Intraoperative bupivacaine, ephinephrine intercostal nerve block	IBR performed with intercostal nerve block alone, no transition to general anesthesia, no opioid pain medications needed
Haydon 2016	A Novel Technique of Intraoperative Lateral Pectoral Nerve Block During Subpectoral Breast Implant Placement	III	Intraoperative lateral pectoral nerve block with ropivacaine	Significantly reduced postoperative pain and opiate requirements
Butz 2015	Postoperative Pain and Length of Stay Loweredby Use of Exparel in Immediate, Implant-Based Breast Reconstruction	III	Intraoperative Liposomal Bupivacaine (Exparel)	Decreased patient VAS pain scores, reduced LOS
Shah 2015	Thoracic Intercostal Nerve Blocks Reduce Opioid Consumption and Length of Stay in Patients Undergoing Implant-Based Breast Reconstruction	III	Intraoperative Thoracic Intercostal Nerve Blocks	Significant reduction in the consumption of pain medication, LOS and in-hospital costs
Coopey 2013	Use of Preoperative Paravertebral Block Decreases Length of Stay in Patients Undergoing Mastectomy Plus Immediate Reconstruction	III	Preoperative Paravertebral Block	Significantly decreased LOS, improved pain control, quicker conversion to oral narcotics because of less postoperative nausea

1:200,000 epinephrine and 4 mg of dexamethasone or (2) sham nerve blocks with normal saline. The authors utilized a 40-item Quality of Recovery score, pain score and opioid use in the post-operative period as the metrics for the efficacy of nerve blockade and subsequently compared statistically between groups. There were no identified statistical differences in quality of recovery, pain burden as measured by the visual analog scale, opioid consumption, antiemetic use, or length of hospital stay between groups at 24 h after surgery. The conclusion made in this study was that intraoperative nerve blocks could be a safe adjunct to a comprehensive postsurgical recovery regimen; however, the trial's results indicated no effect on the overall quality of recovery after TE/implant breast reconstruction. Table 1 summarizes the results from studies in the literature reporting on nerve blocks in IBR.

NSAID pharmacotherapy

Overall, the use of NSAIDs (i.e. ketorolac and ibuprofen) demonstrated good pain control postoperatively as monotherapy in some studies and were not associated with increased hematoma risk. The study by Mikhaylov et al. [38] reported equivocal pain modulation as well as no elevated incidence of hematoma. The study by Le et al. [23] further describes the efficacy of ibuprofen as the lone pharmacotherapy prescribed for pain after tissue expander (TE)/IBR, and also noted that the majority of their patients did not require any pain relief postoperatively. Table 2 demonstrates two studies in which non-steroidal anti-inflammatory drugs (NSAIDs), specifically, ketorolac and ibuprofen, were utilized as pain control measures in IBR.

Implantable local anesthetics

Overall, the use of implantable local anesthetic infusion pumps and eluting devices led to positive patient-reported pain scores in IBR. The study conducted by Chaudhry et al. [31] demonstrated a significant reduction in reported pain scales (Visual Analog Scale) compared to standard analgesia protocols in patients who received the elastomeric pump intraoperatively. These were similar findings to the study conducted by Lu et al. in 2005 [39] that demonstrated a significant association with decreased hospitalizations, pain scores and the number of additional pain medications in the group of patients who received the implantable bupivacaine pump. Table 3 relates two studies that reported on the utilization of implantable local anesthetic infusion pumps containing bupivacaine.

Pain management in ADM and tissue expander breast reconstruction

The study conducted by Gassman et al. [27] identified a significant correlation between greater analgesic dependence postoperatively in the group of patients who underwent TE/IBR compared to those who underwent single-stage DTI reconstruction. Zhu et al. [28], in the same year, compared TE location placement postoperative pain scores, reporting a significantly decreased average pain during admission following surgery in the group who received TE placed in the subcutaneous plane compared to sub-muscular. Table 4 summarizes the findings of studies identified that used acellular dermal matrix (ADM) in conjunction with IBR in the prepectoral plane as a comparative intervention for pain modulation. Table 5 details the two studies identified in the

Table 2. Non-steroidal anti-inflammatory (NSAID) pharmacotherapy in IBR.

First author and year	Title	Level of evidence	Intervention	Outcomes/results
Mikhaylov 2018	Ketorolac and Hematoma Incidence in Postmastectomy Implant-Based Breast Reconstruction	III	Intraoperative ketorolac	No elevated incidence of hematoma
Le 2017	Pain and Anxiety Levels of Patients Undergoing Tissue Expansion After Mastectomies: A Case Series Study	III	Ibuprofen for TE IBR	Ibuprofen was efficacious in pain relief though most patients required no pain relief

Table 3. Bupivacaine pump placement in IBR.

First author and year	Title	Level of evidence	Intervention	Outcomes/results
Chaudhry 2015	Improving Postoperative Pain Management in Subpectoral Tissue Expander Implant Reconstruction of the Breast using an Elastomeric Pump	III	Elastomeric local anaesthetic infusion pump placed intraoperatively	Significantly reduced pain (VAS) reported compared to standard analgesia control group
Lu 2005	The Efficacy of Continuous Local Anesthetic Infiltration in Breast Surgery: Reduction Mammaplasty and Reconstruction	III	Indwelling catheters for the continuous infiltration of local anesthetic (bupivacaine)	Significantly decreased hospitalizations, pain scores and number of pain medications needed

Table 4. Acellular dermal matrix (ADM) in prepectoral implant placement in IBR.

First author and year	Title	Level of evidence	Intervention	Outcomes/results
McCarthy 2012	The Use of Acellular Dermal Matrices in Two-Stage Expander/Implant Reconstruction: A Multi-Center, Blinded, Randomized Controlled Trial	I	ADM-assisted, TE/I reconstruction	Use of ADM in the setting of TE/I reconstruction neither reduces post-operative pain nor accelerates the rate of post-operative expansion
Baker 2018	A Prospective Comparison of Short-Term Outcomes of Subpectoral and Prepectoral Strattice-Based Immediate Breast Reconstruction	II	Prepectoral Strattice-Based IBR	Early postoperative pain and quality of life at 3 months are equivalent between groups
Sorkin 2017	Acellular Dermal Matrix in Immediate Expander/ Implant Breast Reconstruction: A Multicenter Assessment of Risks and Benefits	II	ADM-assisted, TE/I reconstruction	No significant ADM effects on complications, time to exchange or PRO in immediate expander/ implant breast reconstruction
Apte 2015	Single-stage immediate breast reconstruction with acellular dermal matrix: Experience gained and lessons learnt from patient reported outcome measures	II	Direct-to-implant, ADM assisted breast reconstruction, using Strattice	High levels of satisfaction with cosmetic outcomes, low incidences of severe post-operative pain and a short recovery process
Cattelani 2018	One-Step Prepectoral Breast Reconstruction With Dermal Matrix-Covered Implant Compared to Submuscular Implantation: Functional and Cost Evaluation	III	Prepectoral ADM-wrapped IBR	Lower pain intensity and significant upper limb functional advantages compared to submuscular implant placement
Schaeffer 2018	Early Functional Outcomes After Prepectoral Breast Reconstruction: A Case-Matched Cohort Study	III	2-stage, ADM-assisted prepectoral approach vs ADM-assisted, partial submuscular reconstruction	Prepectoral ADM-assisted breast reconstruction can be performed safely and with significantly less pain and earlier return to function than partial submuscular expander placement.

Table 5. Tissue-expander (TE) use in IBR.

First author and year	Title	Level of evidence	Intervention	Outcomes/results
Gassman 2016	Comparison of Immediate Postoperative Pain in Implant-Based Breast Reconstructions	III	Immediate-implant vs TE IBR	TE-based implant reconstruction show greater analgesic use than those with single-stage immediate implant-based reconstruction
Zhu 2016	Comparison of Subcutaneous Versus Submuscular Expander Placement in the First Stage of Immediate Breast Reconstruction	III	Sub-cutaneous vs Sub-muscular TE	Decreased average pain during admission in sub-cutaneous TE group

literature to have reported on comparative pain scores in patients receiving TE/IBR as opposed to direct-to-implant (DTI) reconstruction.

ERAS and intra-operative lipofilling

As alternative methods to pain control in IBR, one study was identified which employed the enhanced recovery after surgery (ERAS), as well as one study that attempted to perform concurrent lipofilling of the breast pocket at the time of implant placement, both of which identified promising results in IBR. Table 6 includes two studies that analyzed pain control in IBR; one study conducted by Dumestre et al. [25] validated the ERAS protocol in this cohort of patients undergoing IBR, reporting improved patient satisfaction, a greater percentage of same-day discharge, lower pain scores and fewer complications. Cuomo et al. [33] published a study in 2014 in which the authors analyzed the effect of concomitant lipofilling intraoperatively at the time of IBR. The study identified 22 patients who received fat transfer during IBR and 18 patients who did not receive any fat transfer, and the reported result was a decreased need for pain medication in the group that received lipofilling.

Discussion

A review of the published works to-date in the current literature on techniques to maximize postoperative pain control in IBR identified several techniques with substantial evidence to support their efficacy. The vast majority of studies reporting the use of intraoperative nerve blocks for pain control in IBR demonstrated a positive effect on the quality of recovery. The use of NSAIDs (i.e. ketorolac and ibuprofen) demonstrated good pain control postoperatively as monotherapy in some studies and were not associated with increased hematoma risk. The two studies reporting the use of implantable local anesthetic infusion pumps containing bupivacaine were found to be associated with decreased hospitalizations, pain scores and several additional pain medications. Concurrent lipofilling during implant placement was also associated in one study with a decreased need for postoperative pain medication. Finally, the one study in which the ERAS protocol demonstrated improved patient satisfaction, a greater percentage of same-day discharge, lower pain scores and fewer complications. With the evidence of positive results on pain modulation in IBR with these techniques, it is critical for plastic surgeons to obtain a fund of knowledge on all the tools available to better address postoperative pain control in this population.

Pre-operative nerve blocks

Pre-operative blockade of nerve receptors has demonstrated to effectively decrease post-operative pain and opioid consumption across a variety of procedures. While technically it may be difficult to perform in all patients and has associated risks (e.g. iatrogenic pneumothorax), its putative benefits are legitimate. Different local anesthetics can be used, but theoretically, the agent should be long-acting and/or part of an infusion. Traditionally, regional blocks or infusions were performed with bupivacaine alone, which has an approximate duration of action between eight to twelve hours. However, there has been recent interest in using liposomal bupivacaine, which can potentially lengthen the analgesic effect anywhere from 72 to 96 h [1]. Although comparative studies evaluating cost and outcomes between these two agents of choice are still necessary, the preliminary evidence certainly demonstrates the heightened efficacy and merit of liposomal bupivacaine in reconstructive breast surgery [2].

Neural modulators

Pre-operative administration of neural modulators, such as gabapentin and pregabalin, has demonstrated to improve pain control and decrease narcotic use following a variety of surgeries, although this has yet to be explored in patients undergoing IBR. The presumed benefit of adding neural modulation pharmacotherapy to the enhanced recovery protocols is through inhibition of nociception and central sensitization following breast reconstruction [3]. We were unable to identify any studies evaluating the independent effects of gabapentin on postoperative pain in breast reconstruction, although there are several meta-analyses indicating its significant analgesic and opioid-sparing effect in surgical patients [3–6]. While the recommended dosage varies, the maximum efficacious dose is 2400 mg daily (either in one dose, or split into thirds throughout the day) [7]. Patients should be assessed for potential co-morbidities that would preclude its use (e.g. hepatitis, congestive heart failure, hypersensitivity).

Perioperative analgesic pharmacotherapy

A number of pharmacological protocols have been introduced into surgical pain control pathways in an effort to decrease narcotic dependence in patients recovering from surgery. Among these, ketamine is a dissociative agent that acts on the NMDA receptor. It has been shown to have questionable efficacy in improving postoperative pain following mastectomy when used alone but has been supported with positive outcomes in combination with local and regional anesthetic nerve blocks [40]. There has been promising data compiled in the literature of other surgical specialties on the positive effects of perioperative ketorolac. A

Table 6. Other studies involving interventions in IBR to optimize pain control.

First author and year	Title	Level of evidence	Intervention	Outcomes/results
Dumestre 2017	Improved Recovery Experience Achieved for Women Undergoing Implant-Based Breast Reconstruction Using an Enhanced Recovery after Surgery Model	III	Enhanced recovery after surgery (day surgery, provided with standardized perioperative education and multimodal analgesia)	Improved patient satisfaction and same-day discharge, less severe pain and nausea, no increase in complications
Cuomo 2014	Postsurgical Pain Related to Breast Implant: Reduction with Lipofilling Procedure	III	Concomitant lipofilling at time of implant-based reconstruction	22 patients undergoing lipofilling for breast recontruction needed less pain medication compared to 18 patients which did not undergo lipofilling

meta-analysis of 13 randomized control trials (RCTs) in a diverse group of surgical patients found that perioperative ketorolac administration significantly reduced postoperative pain and opioid consumption, although this analysis did not account for hematoma incidence between groups [41].

Non-steroidal anti-inflammatory (NSAID) medications have been used as adjuvant pain control medications for most enhanced recovery protocols. Despite previous concerns regarding increased bleeding risk, multiple studies have failed to demonstrate a causative link [23,38]. Main contraindications to NSAID pharmacotherapy would include patients with a history of peptic ulcer disease, gastrointestinal bleeding, alcohol intolerance, renal impairment, or cerebrovascular bleeding (see algorithm, Figure 2). In addition to NSAID therapy, acetaminophen has been suggested as a helpful and safe adjunct to perioperative pain management protocols in breast reconstruction. Acetaminophen use, compared to placebo, has been shown to significantly reduce postoperative pain in surgical patients, both on its own, as well as in combination at various dosages with NSAIDs, lending additional evidence to support the concept of multimodal analgesia protocols [8,9].

Intraoperative nerve blocks

In addition to pre-operative paravertebral and/or epidural infusions, intra-operative injection of local anesthetics has utility in reducing post-operative pain. A variety of agents have been described, including lidocaine, bupivacaine and recently, liposomal bupivacaine. All these agents act on the nerve sodium channel receptors and decrease the transmission of pain signals. For the breast, different injection techniques have been advocated, most notably the pectoral 1 and 2, as well as the serratus block. The pectoralis 1 block following mastectomy is essentially an injection to the pectoralis major muscle and fascia. The pectoralis 2 block is an injection between the pectoralis major and minor muscles. Finally, the serratus block includes an injection at the rib level laterally at the level of the 4th rib.

Contrasting evidence comes from older retrospective cohort studies and one RCT that did claim the value of intraoperative paravertebral blocks (PVBs) versus general anesthesia alone. Coopey et al. [10] demonstrated reductions in LOS, perioperative opiate use and postoperative pain for patients undergoing immediate prosthetic breast reconstruction with a PVB compared to patients who did not receive a PVB [10]. These regional analgesic procedures can be performed and taught easily with minimal risk for complications [11]. Similar to the TAP block, the anatomical and technical considerations for performing PVBs has been thoroughly described in the literature and applied to patients undergoing IBR [12].

Early activity ambulation

Although no studies were identified which evaluate the independent impact of early ambulation on recovery outcomes in patients undergoing IBR, the limited studies in the broader surgical literature indicate potentially decreasing postoperative length of stay and vascular thrombosis complications, early activity and physical therapy have been shown to positively affect post-operative pain with early mobilization emphasized as soon as a postoperative day (POD) 1 [13–15]. While the risks of early ambulation remain unclear, the potential benefits include alleviating the risk of associated adverse events with delayed ambulation, including venous thromboembolism, pulmonary deconditioning and muscle weakness [13]. While early ambulation protocols may be more challenging to implement in autologous, abdominally-based breast reconstruction, IBR likely would lend well to early mobilization and would probably require less physical therapy or nursing assistance in the immediate postoperative period.

Muscle relaxants

Muscle relaxants modulate and minimize post-operative pain related to muscle irritation and spasm following surgical manipulation. One area of study which has gained recent attention is the intraoperative injection of onabotulinum toxin type A at the time of implant placement to achieve both a muscular paralytic and analgesic effect [42]. There have been prior reports of successful use of various relaxant agents (i.e. low-dose rocuronium) to optimize perioperative and intraoperative mastectomy outcomes [16,17]. Future directions for studies in this topic could include comparative analyses on different IBR techniques that manipulate the pectoralis muscle (sub-muscular plane) versus pre-pectoral (sub-glandular, sub-fascial) approaches to implant placement. With recent renewed interest in pre-pectoral breast reconstruction, the conversion to a pre-pectoral placement may decrease pain by altering the compression of nerves and or decreasing the muscle pain associated with submuscular implant placement. Even looking beyond pharmacotherapy for postoperative chest wall muscular pain, selective neurectomy of irritated, symptomatic nerves could be targeted and decompressed or treated by shielding/grafting the nerves [43]. This approach to pain control would be especially important to consider in TE/IBR, as this technique tends to be associated with significant pain related to pectoralis myospasms.

Anti-emetic medications

Given during the peri-operative period, anti-emetic agents such as ondansetron and promethazine can assist in post-operative pain. While there are a number of agents with proven antiemetic

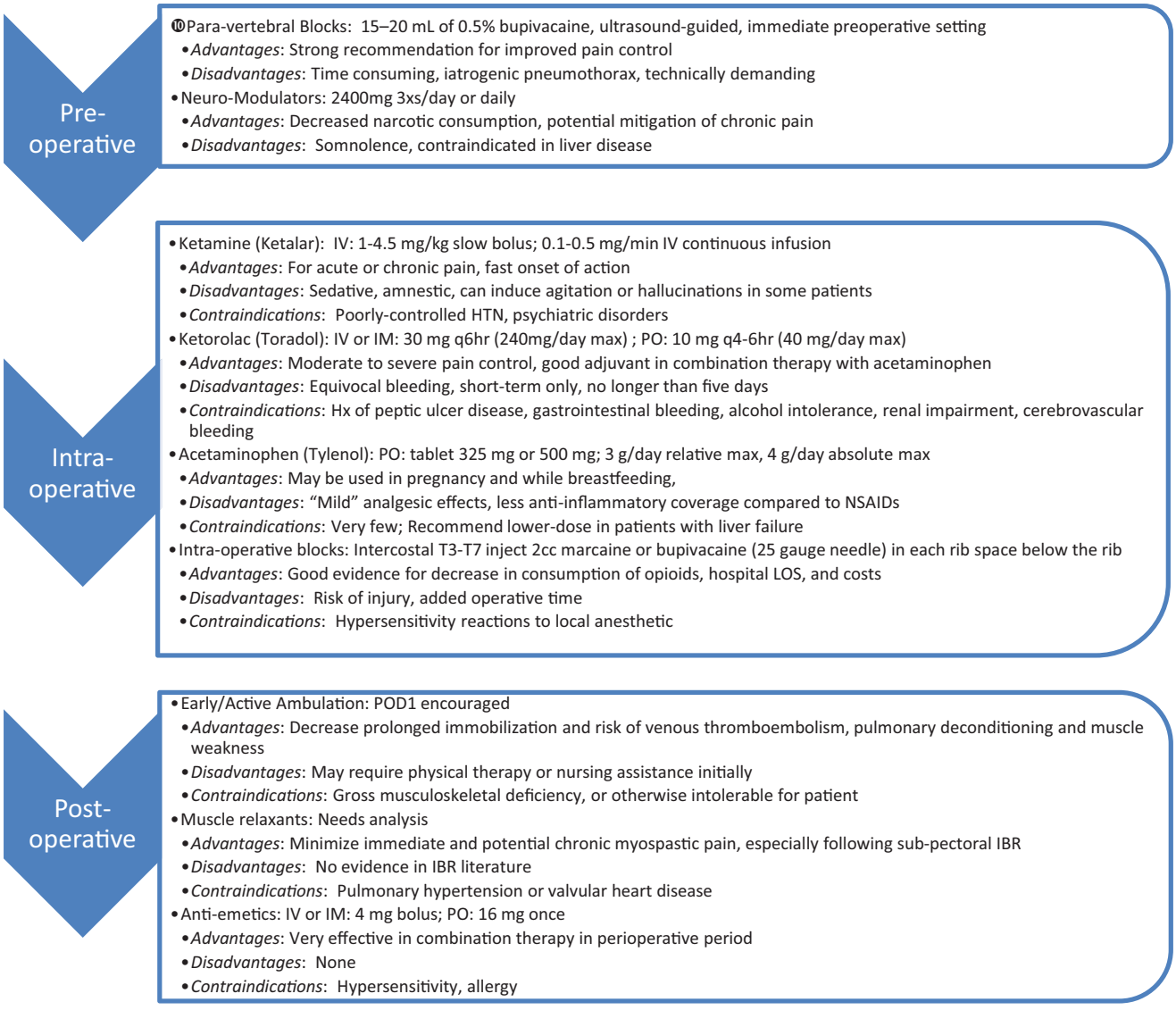

Figure 2. Algorithm for optimized pain control in IBR.

effects, the best evidence supports 5-HT3 receptor antagonists (e.g. ondansetron), dexamethasone and transdermal scopolamine. This has been demonstrated through recent meta-analyses showing independent efficacy in reducing postoperative nausea and vomiting when administered prophylactically [44–46]. Combination prophylaxis versus single-agent prophylaxis has been studied in the aesthetic surgery patient population and has demonstrated a benefit to combination therapy; however, various combinations used and differences in patient populations have yet to be analyzed in-depth [44,46].

Algorithm

Based on the review of the current literature presented, we propose an algorithm (Figure 2) for optimized pain control in IBR, highlighting evidenced-based guidelines as seen in the cited studies analyzed in this review. Similar algorithms have been utilized in plastic surgery literature, and have shown promise to guide evidence-based clinical care [47,48].

Limitations

There are several notable limitations of the presented study. First, the body of literature surrounding postoperative pain control in IBR is limited, with the vast majority of publications being small, single-center, retrospective studies. This makes drawing conclusions from pooled data difficult, given the substantial heterogeneity in factors contributing to the management and outcomes reported in each study. As such, our review is limited by what the literature can offer us. Furthermore, there is a potential for bias in interpreting the data reported in each study, as it is possible that not all studies captured reliable comorbidity data or pain outcomes over a long period of time. Follow-up times are also a limitation of the study, as follow-up was limited to what the literature allowed. Finally, in line with the aim of our study, we elected to not include studies that may have been suggesting certain techniques for pain control following IBR that did not include objective, reportable findings to evaluate the efficacy of such techniques. By excluding articles failing to report results on pain scored before

and after the intervention, we had greater confidence in the evidence presented in this review. We felt it prudent to avoid meta-analytic statistical measures to draw firm conclusions on the associations drawn from this study. Furthermore, there are limitations intrinsic to the systematic review process, such as reporting bias, as well as incomplete retrieval of relevant studies and data. Larger, randomized, multicenter studies are warranted to validate the associations found in each study identified in this updated review of the literature.

Conclusions

Pain control has come to the forefront of social consciousness with the massive opioid epidemic resulting in numerous deaths and chronic morbidity. Poor pain control and prolonged opioid use have been thought to be the nidus for chronic pain and opioid abuse. Therefore, the goal of the current article is to present a comprehensive pain treatment review and algorithm in patients who undergo implant-based breast reconstruction. As this topic of investigation continues to grow, we hope to see evidence-based guidelines, recommendations and algorithms available for plastic surgeons to reference while caring for and maintaining the safety of their patients.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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