Still ESPEculating

Aún ESPeculando

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In 2016, a report of 4 cases described a novel interfascial block in relation to the erector spinae muscles (ESMs). The block was used for the treatment of chronic chest pain syndromes with good results[1]. Today, after a quick search in Pubmed, it is possible to find more than 700 publications referring to the subject, which has also become a topic that cannot be missed in any meeting of regional anesthesia. Its technical simplicity and the broad spectrum of potential indications have made the blockade of this plane, the Erector Spinae Plane Block (ESPB), the most popular tool in the regional anesthesia armamentarium nowadays.

Its application has been described from the neck[2] to the sacrum[3], in chronic pain conditions[1], and surgeries ranging from the upper limb[4] to the lower limb[5], passing through the thorax[6], abdomen[7] and pelvis[8]. Thus, the ESPB has become some sort of magic bullet for perioperative analgesia. However, despite its great popularity and abundance of publications, there are still unknown or unclear aspects regarding its mechanism of action, technical elements, efficacy, effectiveness, efficiency, safety profile, and finally, the spectrum of procedures for its indication[9].

Anatomical foundations

The ESMs are the spinalis (medial), the longissimus (middle), and the iliocostalis (lateral) and represent the intermediate muscular layer of the intrinsic muscles of the spine. The ESMs originate caudally in the iliac crest, the sacrum, and the processes of the lumbar spine. They ascend on each side of the spine between the spinous processes (medially) and the angles of the ribs (laterally). Rostrally, the spinalis attaches to the skull and upper thoracic spinous processes. The longissimus attaches to the thoracic ribs, thoracic and cervical transverse processes, and the mastoid process. The iliocostalis attaches to the costal angles and cervical transverse processes[9].

The technique described by Forero et al. seeks to deposit a mass of local anesthetic (LA) in the deep myofascial plane to the erector spinae muscles, using as visual ultrasonographic aid its intimate relationship with the transverse vertebral process on its lateral border[1] and injecting between the latter and the ESM, what has been defined as the erector spinae plane (ESP). Initially, the hypothesis was that from this point on, the LA would diffuse towards the paravertebral space (PVS)[10],[11] and also to the epidural space (ES)[12].

Three physical barriers exist between the ESP and the thoracic PVS, the intertransverse ligament, the intertransverse muscle, and the superior costotransverse ligament. These barriers are not all present along the spine and are not necessarily one hundred percent impermeable. These data correlate with findings of variable staining/contrast diffusion depending on the injection level; regions such as the lumbar area and the middle thoracic region demonstrate minimal or non-existent impregnation of the ventral branch compared to the posterior branch[9]. In turn, the anterior branch is impregnated more frequently in other levels (although inconstantly and tenuously).

In cadaveric studies, staining has diffused partially to the PVS[13],[14] and ES at some levels[15]. The problem with studies of this type is that the technique has not been standardized and that the results can be altered during dissection, generating artificial staining of tissue planes[16],[17]. Furthermore, as the cadaver lacks the myofascial functionality of the living model, it does not allow to objectify the evolution of the injectate diffusion before its absorption and elimination.

Anatomical studies based on imaging have shown similar results. Thus, in an immediately post-blockage photograph, the injectate mainly remains in the paraspinal muscles and intermuscular planes with a variable, but in general scarce, presence of contrast in the PVS and ES[18],[19], although insufficient to generate an epidural block (EB) or a paravertebral block (PVB) clinically equivalent to their direct versions.

Unfortunately, static imaging in cadaveric models does not address whether the ESP has a reservoir effect from which anesthetics keep diffusing for a certain period to other anatomical planes.

A theoretical advantage of live imaging studies with contrast dye administration is that muscle planes and tonicity are preserved, generating reliable injectates diffusion. It also has the potential to evaluate the evolutive profile of contrast at different timeframes after its deposit, which could unravel the mystery behind the theory of the reservoir effect and indirect epidural and paravertebral block. However, no study has repeated an image control in a live model to elucidate this question.

A disadvantage of imaging is the fact that it cannot precisely

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distinguish the location of the contrast used. Thus, intercostal contrast can either be intravascular, lymphatic, intermuscular, or intramuscular. Something similar can occur in the paravertebral and prevertebral spaces[17]. Besides, the pharmacokinetics of the injected contrast dye will not necessarily correlate with that of a LA.

Pharmacological analysis

In regional anesthesia, the basis for the success of a technique is to surround (and ideally keep surrounded) the neural target with LA, which also requires effective doses of these drugs for a specific site of action[20],[21]. The PVS was initially theorized as the final action site of the ESPB, although with a variable degree of epidural diffusion. The volume of the injectate solution may correlate to the anesthetic reaching the PVS and perhaps the ES[14].

From experience with epidural analgesia, it is improbable that an adequate single dose of LA will maintain an effect longer than a couple of hours at this level. Thus, a continuous infusion (or at least periodic reinforcement of anesthetics) is needed in an adequate volume and concentration. Currently, it is also clear that a continuous epidural infusion is insufficient to maintain optimal analgesia extension. Repeated boluses administered either by patients´ demand or programmed doses (or both) may represent the best modality[22]. These boluses must also have a determined flow that is only allowed with infusion pressures that are improbable to achieve with paraspinal muscle movements or with negative intrathoracic pressure, both mechanisms speculated for the ESPB reservoir-infuser effect[17].

When performed without ultrasound guidance, PVB always required high volumes and concentrations plus a precise injection into the PVS to correlate with an optimal effect. Furthermore, to ensure multilevel analgesia, different level injections were frequently preferred[23]. After introducing ultrasonography, multiple variants have appeared for PVB thanks to the direct visualization of injection sites[24], although with little progress defining effective doses and ideal techniques. However, in general, volumes close to 20 mL per side are still used, a key element to consider when looking for a similar result but injecting in a more distant spot.

Other studied pharmacological aspects of ESPB have shown that by increasing the mass of the drug while keeping the volume constant, the block may turn more effective[14]. Besides, the block could be enhanced with adjuvants such as dexmedetomidine[9]. However, these studies do not allow to elucidate the actual site of action of these drugs.

After injection into the ESP, LA systemic effect has also been proposed as responsible for at least part of the ESPB analgesic effect. However, no studies analyzing the plasma concentrations of LA after ESPB have been published. Whether these concentrations resemble the effective levels achieved, for example, with intravenous lidocaine, is unknown.

More hypotheses on the mechanism of action additionally exist. Some have postulated the role that fascias could play as functional organs modulating pain favored by LAs injected in its proximity. Also speculative is the theory of how low doses of LA, like the ones reaching the PVS and ES after ESPBs, could still generate relevant effects in the context of neural blockade and neuromodulation[17]. Nevertheless, for blocks primarily seeking anesthesia and perioperative analgesia, ineffective doses are not used deliberately in everyday practice. Thus, taking risks of invasive procedures like nerve blocks just looking for unproven effects seems unethical.

Clinical evidence

Albeit not in an all-or-nothing mode and with some inter and intrapersonal variability, regional anesthesia allows a reasonably objective analysis of the neural block's somatic component by evaluating the cutaneous sensory block. Regarding motor blockage, this is easier to objectify at the level of the extremities, although it also occurs in the trunk. Similar to what happens to the motor aspect occurs as well to the autonomic blockade. Thus, one of the main difficulties in the chest and abdomen is to objectify the visceral component of the block, which in some surgeries is the most relevant, especially when the parietal approaches are minimally invasive.

ESPB studies that have assessed cutaneous sensory block offer some clues that contribute to understanding this technique. From the first report by Dr. Forero[1], something was evident to a perceptive observer. The cutaneous distribution of the block was absent at the parasternal region. This fact was also demonstrated in clinical series, volunteer series, and at least one randomized study where parasternal skin block was inconsistent with ESPB[25],[26],[6]. Furthermore, to date, none of the other published studies have proven the opposite (the existence of consistent and durable parasternal skin blockade).

Anatomically, the absence of parasternal cutaneous block in the presence of dorsal and sometimes lateral cutaneous blockade indicates that the ESPB achieves an adequate block of the posterior branch in a variable number of ipsilateral spinal nerves (quite logical given the injection site) and probably the blockade of the lateral cutaneous branch of some intercostal nerves (understandable due to a lateral interfascial diffusion). However, it would not block, or not with the same density, the ventral branch of the spinal nerves (at least not with injections at certain levels of the spine). The ventral branch is the one that will give rise to the respective intercostal nerve and will finally emerge at the parasternal level, innervating the skin of this region. These facts go against the theoretical effect of ESPB as an indirect blockade of the PVS. Secondarily, the ESPB would not generate a relevant autonomic block either and thus, would not produce visceral analgesia or other benefits described with EB and PVB. In this manner, at least at the levels shown by the studies described, it's likely that ESPB has rather a dorsolateral parietal somatic effect, which is more than enough to explain the multiple clinical reports of analgesic benefits in procedures that involve these regions.

The best available evidence

When ethics allow it and the needed sample size is reasonable, blinded and multi-center randomized clinical trials (RCTs) are considered the best methodology to test a research hypothesis for a relevant question. In the case of regional blocks,

most of the time, it is perfectly possible to design ethically correct studies with an appropriate methodology to demonstrate the effectiveness of a technique in terms of an outcome such as perioperative analgesia. To date, of the more than 700 PubMed publications, only 41 meet RCT criteria (platform criteria). A similar search in another database (Embase) returns more than 600 articles, of which 92 classify as RCT. A recent review published this year[9] analyzed the 55 RCTs existent at the moment in peer-reviewed journals available in Medline, Embase, and Google Scholar. Twenty-three studies compared ESPB against sham blockades or nothing, and twenty-two studies compared it against other blocks in specific surgeries. Two aspects stand out from this review. The first is that two-thirds of these articles were eliminated from the analysis because they didn't meet the minimum necessary standards to avoid significant bias in the results (prospective registry, randomization, blinded outcome analysis, discrepant sample sizes). The second important aspect was that the studies comparing ESPB with sham blocks or nothing found differences more statistically than clinically significant. Besides, adjuvant multimodal analgesic regimens were infrequent in these studies. Thus, the actual analgesic contribution of ESPB has been questioned, even concluding a role only for surgeries with a low pain burden[16]. Alternatively, studies comparing ESPB with other regional techniques with a proven analgesic role have tended to show analgesic equivalence in minimally invasive procedures or posterolateral areas of the trunk[9]. Well-designed trials comparing ESPB against validated regional alternatives (epidural block, paravertebral block, PEC-Serratus) in open anterior thoracoabdominal surgery are still lacking.

To fuel the controversy, a recent meta-analysis of ESPB in breast cancer surgery (where the main site of surgical damage is in the lateral region of the trunk innervated by the lateral cutaneous branch of the intercostal nerve) highlights the fact of the statistically significant effect of ESPB, although clinically not very relevant when associated to adequate systemic analgesia[22].

Low-level evidence: Opinion

There is a strong bias in writing about ESPB being an operator with adequate expertise with epidural and paravertebral blocks. Consequently, it is not easy to find instances to execute a thoracic ESPB instead of these other options. While performing ultrasound-guided paravertebral injections, it is hard to choose to stay halfway and deposit the LA in the ESP when there are still too many doubts about it. However, understanding the difficulty of mastering the gold standards of truncal blocks makes it easier to understand why an alternative like ESPB today, or PEC-Serratus blocks before, became so popular. Finally, what is more important? Just a few patients having optimal analgesia based on a risky and challenging technique that just some are regularly performing, or most patients receiving fair analgesia thanks to a widely applicable and safe technique. Despite all the inconsistencies, ESPB has consistently generated adherence among its users. Many ESPB users and promoters (or believers) possess even more experience than this author in paravertebral and epidurals blocks. This fact cannot be omitted that easily. After reviewing the evidence and executing ESPBs in specific scenarios, the speculative theory of a somatic posterolateral truncal wall effect makes sense. An effect explained by the consistent blockage of a variable amount of posterior branches of ipsilateral spinal nerves and possibly, a variable extension to the lateral cutaneous branch of the intercostal nerve, achieving a similar effect to the serratus plane block. To these mechanisms, it can be added, at least until proven otherwise, the systemic effect, the fascial modulator role, or any new theory circulating at the time.

Finally, the best balance of expertise and evidence weighting adequately efficacy, efficiency, and safety must prevail for any anesthetic practice. If ESPB becomes the first option to offer to patients in a given setting, the operator then must be convinced that if being a patient in the same scenario, it would also be the first choice to request.

Referencias

1. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med 2016; 41: 621-627.
2. Forero M, Rajarathinam M, Adhikary SD, Chin KJ. Erector spinae plane block for the management of chronic shoulder pain: a case report. Can J Anaesth 2018; 65(3): 288-293.
3. Tulgar S, Senturk O, Thomas DT, Deveci U, Ozer Z. A new technique for sensory blockage of posterior branches of sacral nerves: Ultrasound guided sacral erector spinae plane block. J Clin Anesth. 2019 Nov;57:129-130.
4. Hamadnalla H, Elsharkawy H, Shimada T, Maheshwari K, Esa WA, Tsui BC. Cervical erector spinae plane block catheter for shoulder disarticulation surgery. Can J Anesth 2019; 66: 1129-1131.
5. Lennon MJ, Isaac S, Currigan D, O'Leary S, Khan RJK, Fick DP. Erector spinae plane block combined with local infiltration analgesia for total hip arthroplasty: A randomized, placebo controlled, clinical trial. J Clin Anesth. 2021 May;69:110153.
6. Taketa Y, Irisawa Y, Fujitani T. Comparison of ultrasound guided erector spinae plane block and thoracic paravertebral block for postoperative analgesia after video-assisted thoracic surgery: a randomized controlled non-inferiority clinical trial. Reg Anesth Pain Med 2019;Nov 8:rapm-2019-100827.
7. Aygun H, Kavrut Ozturk N, Pamukcu AS, Inal A, Kiziloglu I, Thomas DT, Tulgar S, Nart A. Comparison of ultrasound guided Erector Spinae Plane Block and quadratus lumborum block for postoperative analgesia in laparoscopic cholecystectomy patients; a prospective randomized study. J Clin Anesth. 2020 Jun;62:109696.
8. Lin C, Gill R, Kumar K. Bilateral lower thoracic erector spinae plane block in open abdominal gynecologic oncology surgery: a cases series. Rev Bras Anestesiol 2019 Sep-Oct;69(5):517-520.
9. Saadawi M, Layera S, Aliste J, Bravo D, Leurcharusmee P, Tran DQ. Erector spinae plane block: A narrative review with systematic analysis of the evidence pertaining to clinical indications and alternative truncal blocks. J Clin Anesth 2021 Feb;68:110063.
10. Chin KJ, Malhas L, Perlas A. The Erector Spinae Plane Block Provides Visceral Abdominal Analgesia in Bariatric Surgery: A Report of 3 Cases. Reg Anesth Pain Med 2017; 42(3): 372-376.
11. Costache I, Pawa A, Abdallah FW. Paravertebral by proxy - time to redefine the paravertebral block. Anaesthesia 2018;73(10):1185-1188.

12. Yang HM, Choi YJ, Kwon HJ, O J, Cho TH, Kim SH. Comparison of injectate spread and nerve involvement between retrolaminar and erector spinae plane blocks in the thoracic region: a cadaveric study. Anaesthesia 2018; 73(10):1244-1250.
13. Nielsen MV, Moriggl B, Hoermann R, Nielsen TD, Bendtsen TF, Børglum J. Are single-injection erector spinae plane block and multiple-injection costotransverse block equivalent to thoracic paravertebral block? Acta Anaesthesiol Scand 2019; 63(9):1231-1238.
14. Choi YJ, Kwon HJ, O J, Cho TH, Won JY, Yang HM, Kim SH. Influence of injectate volume on paravertebral spread in erector spinae plane block: An endoscopic and anatomical evaluation. PLoS One 2019 28;14(10):e0224487.
15. Adhikary SD, Bernard S, Lopez H, Chin KJ. Erector Spinae Plane Block Versus Retrolaminar Block: A Magnetic Resonance Imaging and Anatomical Study. Reg Anesth Pain Med. 2018; 43(7):756-762.
16. Lonnqvist PA, Karmakar MK, Richardson J, Moriggl B. Daring discourse: should the ESP block be renamed RIP II block? Reg Anesth Pain Med 2021; 46(1):57-60.
17. Chin KJ, El-Boghdadly K. Mechanisms of action of the erector spinae plane (ESP) block: a narrative review. Can J Anaesth 2021; 68(3):387-408.
18. De Lara González SJ, Pomés J, Prats-Galino A, Gracia J, Martínez-Camacho A, Sala-Blanch X. Anatomical description of anaesthetic spread after deep erector spinae block at L-4. Rev Esp Anestesiol Reanim 2019; 66(8): 409-416.
19. Elsharkawy H, Bajracharya GR, El-Boghdadly K, Drake RL, Mariano ER. Comparing two posterior quadratus lumborum block approaches with low thoracic erector spinae plane block: an anatomic study. Reg Anesth Pain Med 2019; 28: rapm-2018-100147.
20. Tran DQH, Techasuk W, Finlayson RJ. Elicitation of Paresthesia, Peripheral Nerve Stimulation and Intraneural Injection New Insight Provided by Ultrasonography. Advances in Anesthesia 2013; 31(1): 1-19.
21. Saranteas T, Finlayson RJ, Tran DQ. Dose-finding methodology for peripheral nerve blocks. Reg Anesth Pain Med 2014; 39(6): 550-555.
22. Hussain N, Lagnese CM, Hayes B, Kumar N, Weaver TE, Essandoh MK, Reno J, Small RH, Abdallah FW. Comparative analgesic efficacy and safety of intermittent local anaesthetic epidural bolus for labour: a systematic review and meta-analysis. Br J Anaesth 2020; 125(4): 560-579.
23. Aliste J, Baeza F. Bloqueo Paravertebral Torácico. Rev Chil Anest, 2011; 40: 263-271.
24. Krediet AC, Moayeri N, van Geffen GJ, Bruhn J, Steven Renes, Paul E Bigeleisen, Gerbrand J Groen. Different Approaches to Ultrasound-guided Thoracic Paravertebral Block: An Illustrated Review. Anesthesiology 2015; 123(2): 459-74.
25. Taketa Y, Irisawa Y, Fujitani T. Ultrasound-guided erector spinae plane block elicits sensory loss around the lateral, but not the parasternal, portion of the thorax. J Clin Anesth 2018; 47: 84-85.
26. Zhang J, He Y, Wang S, Chen Z, Zhang Y, Gao Y, Wang Q, Xia Y, Papadimos TJ, Zhou R. The erector spinae plane block causes only cutaneous sensory loss on ipsilateral posterior thorax: a prospective observational volunteer study. BMC Anesthesiol. 2020; 20(1):88.