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EVALUATION OF TRANSVERSUS ABDOMINIS BLOCK AND SERRATUS BLOCK REGIONAL ANESTHESIA IN DOGS UNDERGOING MASTECTOMY

VALUTAZIONE DELLA COMBINAZIONE DEL BLOCCO DEL TRASVERSO DELL'ADDOME CON IL BLOCCO DEL SERRATO IN CORSO DI MASTECTOMIA NEL CANE

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SUMMARY:

RIASSUNTO:

Scopo del lavoro:

Questo studio ha come finalità valutare la gestione del dolore in cani sottoposti a mastectomia monolaterale totale utilizzando blocchi ecoguidati del muscolo serrato e del muscolo trasverso con approccio paracostale e ombelicale.

Introduzione:

La mastectomia è il gold standard per trattare i tumori mammari. L'approccio chirurgico è scelto in base alle dimensioni del tumore, alla localizzazione anatomica e allo stato di salute del paziente.

Nei cani lo stimolo algico durante la mastectomia è elevato, per la sua estensione e il coinvolgimento di svariate strutture anatomiche come la cute, sottocute e i muscoli superficiali.

È sì opportuno ridurre il consumo di anestetici e analgesici per minimizzare gli effetti collaterali, ma è fondamentale trattare il dolore. Questo giustifica l'utilizzo degli anestetici locali che permettono di ridurre l'utilizzo di farmaci durante le procedure chirurgiche.

Gli anestetici locali hanno la capacità di bloccare gli stimoli nocicettivi a livello delle fibre nervose prevenendo così la sensibilizzazione a livello centrale.

Materiali e metodi:

Sono stati inclusi nello studio 17 cani femmine di varie razze ed età, sottoposti a chirurgia di mastectomia monolaterale totale. I soggetti sono stati premedicati con metadone (0,2 mg/kg EV). Dopo venti minuti, il paziente è stato indotto con propofol ad effetto. L'anestesia generale è stata mantenuta con isofluorano.

Prima dell'inizio della chirurgia sono stati effettuati tre blocchi: serrato superficiale, TAP block, (approccio paracostale e ombelicale), con ropivacaina diluita allo 0,35% con soluzione fisiologica per un volume pari a 0,3 ml/kg per il serrato e 0,15ml/kg in due siti per il TAP block.

Durante la procedura sono stati monitorati frequenza cardiaca (FC), frequenza respiratoria (FR), pressione arteriosa sistolica (PAS), pressione arteriosa media (PAM), pressione arteriosa diastolica

(PAD), concentrazione espirata di isofluorano (FeISO) e di anidride carbonica (EtCO2), a tempi chirurgici prestabiliti. La valutazione del dolore postoperatorio è stata effettuata mediante scala di Glasgow, fino alla quinta ora post chirurgia.

Risultati e discussione:

Per quanto riguarda i parametri di FC, FR, PAM FeISO ed EtCO2 non sono state registrate variazioni significative. La rescue analgesia intraoperatoria è stata eseguita con boli di fentanil da 1 μg/kg. In 7 casi su 17 non sono stati somministrati boli di fentanil, due casi ne hanno ricevuti tre di boli, un caso ne ha ricevuti due e infine 7 ne hanno ricevuto solo uno.

Nessun paziente ha necessitato di rescue analgesia nel periodo postoperatorio.

Conclusioni:

Da questo studio è emerso che la combinazione del blocco del serrato e del trasverso dell'addome è effettivamente in grado di bloccare lo stimolo nocicettivo della parete del torace e dell'addome nei cani sottoposti a mastectomia totale monolaterale.

ABSTRACT:

Aim of study:

This study aims to evaluate the pain management in dogs affected by mammary tumors that underwent a total monolateral mastectomy procedure with a combination of ultrasound guided blocks of serratus superficial plane block and Trasversus plane block (both paracostal approach and umbelical).

Introduction:

Mastectomy is considered, in dogs, the gold standard for treating mammary tumors. The surgical approach mainly depends on size of the tumor, anatomical localization and health status of the patient.

In dogs, algic stimulus during mastectomy is considered to be elevated because of its extension and involvement of many anatomical structures such as skin, subcutis, and sometimes also superficial muscles.

Thus, if it is mandatory to reduce the dosage of anesthetics and analgesic drugs to minimize their side effects, it is also mandatory to prevent and treat pain. Loco-regional anesthesia is widely used to reduce drug doses in animals undergoing various surgical procedures.

Local anesthetics have the capacity of blocking nociceptive signals of the nervous fiber and preventing central sensibilization.

Materials and methods:

17 female dogs undergoing a monolateral total mastectomy were enrolled in this study. All patients were premedicated with methadone 0.2 mg/kg IV, induced with propofol 20 minutes after premedication, and the general anesthesia was maintained with isofluorane.

Before surgery, the following three blocks were performed: serratus superficial plane block and TAP block (paracostal and umbilicus approach). Ropivacaine was diluted at 0.35% with saline

solution NaCl; the volume used for the serratus was 0.3 ml/kg and for the TAP was 0.15 ml/kg in both sites.

During the surgical procedure for each patient a monitoring every five minutes was made, with multiparametric intra-operative monitoring of heart rate (HR), respiratory rate (RR), partial saturation of oxygen levels, invasive systolic pressure (SAP), invasive mean pressure (MAP), invasive diastolic pressure (DAP), CO_2 concentration at the end of expiration, concentration of expirated isofluorane (FeISO).

Afterward, all patients underwent a multiparametric evaluation of pain via the Glasgow Composite Pain Scale (GCPS-SF: Glasgow Composite Pain Scale) every hour five times after surgery. If the total score was over 5, a rescue analgesia was administered with methadone 0.2 mg/kg IM.

Results and discussion:

No significant differences were recorded in HR, MAP, SAP, DAP, and $EtCO_2$. And 7 out of 17 cases did not require any additional analgesia during the procedure, two cases needed 3 boluses of Fentanyl at 1 mcg/kg, one case needed 2 boluses, and last but not least 7 out of 17 only one bolus.

No rescue postoperative analgesia was needed.

Conclusion:

In this study the combination of serratus plane block and transverse plane block was effective in blocking the nociceptive stimuli in both thoracic and abdomen wall in dogs undergoing a monolateral total mastectomy.

INTRODUCTION:

Mastectomy is considered, in dogs, the gold standard for treating mammary tumors (Sleeckx N. 2011). The canine mammary glands are divided into two mammary lines that start from the trunk and extend until the lower abdomen. There are usually 5 pairs of mammary glands, but this can change and generally there's between 4 and 6 pairs (Lahuta A. 2013). Mammary tumors are the most frequent type of cancer in female dogs, and the surgical procedure is followed by a histological diagnosis. Mastectomy can be considered resolutive if the surgical margins are histologically clean and there are not any signs of metastasis (Fossum C.S. 1997).

The surgical approach to this pathology mainly depends on the size of the tumor, and also from the anatomical localization and health status of the patient. The main surgical procedures performed are as listed: nodulectomy, regional mastectomy, monolateral mastectomy, and total mastectomy, there can be even a bilateral mastectomy but it is usually not performed (Fossum C.S. 1997).

When the inguinal mammary gland needs to be removed, it is also suggested that even the regional lymph node must be removed, because it usually drains the gland. The removal of the axillary lymph node is suggested when the first, second and third mammary gland is affected, although it is difficult to approach due to the presence of the brachial plexus (Meuten D.J. 2002).

In dogs, algic stimulus during mastectomy is considered to be elevated, because of its extension, and the involvement of many anatomical structures such as, the skin, the subcutis and sometimes also the superficial muscles (Teixeira L.G. 2018). It has been demonstrated that the patient can experience painful sensation also prior to surgery, and this can largely affect the post-operative healing which is also affected by various pathology and metabolic problems, all these problems can lead to increase pain (Salazar V. 2015).

Even in human medicine, 60% of women undergoing a mastectomy, reported that they have experienced both acute and chronic pain (Andersen H.K.G. 2011).

Thus, if it is mandatory to reduce the dosage of the anesthetics and analgesic drugs to minimize their collateral side, it is also mandatory to prevent and treat pain. Loco-regional anesthesia is widely used to reduce drugs doses in animals undergoing various surgical procedures (Roberts 2006). Local anesthetics have the capacity of blocking nociceptive signals of the nervous fiber, and preventing central sensibilization. The benefits of such procedure are widely reported in literature, both in human beings and animals. In fact, current guidelines underscore that loco-regional anesthesia is always recommended for pain management (Epstein M. 2015) (Mathews K. 2014).

Local anesthetics may be combined with opioids, alfa2-agonist, dissociative medicine and FANS, local anesthetics are usually used in a multimodal approach for pain management (Lemke and Dawson, 2000).

Monolateral or total mastectomy, requires an incision of the trunk and abdominal wall. The transverse abdominal bock (TAP block) is a locoregional anesthesia technique that desensitizes the abdominal wall and is usually employed for many surgical procedures in human beings (Abdallah F.W. 2012). Even in veterinary medicine TAP block is effective and the local anesthetic is injected between the transverse muscle and the internal oblique muscle (Rafi A.N. 2001), (Taylor R. 2013). This means that the local anesthetic distributes into the ventral branches of the thoracic-lumbar nerves located into this fascia. This technique is considered effective for the following surgical procedures of the abdominal wall: laparoscopy, mastectomy both partial and total in dogs (Schroeder L.B.C. 2011) (Bruggink S.M. 2012) (Portela D.A. 2014). In human patients the serratus muscle block (SP block) is used for mastectomy, thoracotomy, and post operative pain and management of pain in ribs fracture (Kunhabdulla N.P. 2014) (Madabushi R. 2015) (Calì Cassi L. 2017) (Mayes J. 2016) (Zocca J.A. 2017) (Xia L.Y. 2021) (Suman Arora 2022). SP block is made by injecting the local anesthetic in the fascia of the serratus dorsalis cranialis muscle (Blanco R. 2013). In veterinary medicine there is also one paper on the combination of both blocks in total mastectomy, meaning that both the TAP and serratus block have been used in monolateral mastectomy (Teixeira L.G. 2018).

The aim of the present thesis is to evaluate the effectiveness of TAP block combined with SP block for pain management of dogs undergoing monolateral mastectomy.

CHAPTER I: LOCAL ANESTHETICS:

When local anesthetics are applied in appropriate concentrations, they reversibly depress conduction in peripheral nervous tissue. Because of their enviable record of efficacy and safety in producing insensibility to pain in various regions of the body, local anesthetics are also administered through many routes of administration. This feature makes them versatile. Furthermore, since all excitable tissues are susceptible to local anesthetic block, these drugs may be also used systemically as antiarrhythmic agents for general anesthesia. The first local anesthetic used was cocaine: in 1884 its efficacy was demonstrated by Carl Koller, and it was used for the first time as part of an anesthetic protocol for mandibular anesthesia by William Halsted (Liljestrand G. 1971).

Local anesthetics are a group of chemically related compounds that reversibly bind with sodium channels so that they can block impulse conduction in nerve fibers. This mechanism can prevent or reduce pain or nociceptive input during and after surgery (Tranquilli W.J. 2007).

Chemical structure:

There are many classifications of the local anesthetic agents: the first is based on chemical structure (esters or amides), the second on onset of action (fast or slow), and the last but not least on duration of action (short or long).

All local anesthetics share the following common chemical structure: a lipophilic unit is linked to a hydrophilic unit by an intermediate hydrocarbon chain that contains either an ester or an amide group. The lipophilic group is typically an unsaturated ring (such as a benzene), and this structure gives to local anesthetic molecules the ability to cross nerve cell membranes after they are administered outside the cells. The intermediate chain may be formed by either an ester or an amide group, which affects the synthesis and metabolism of the drug. Consequently, the intermediate chain is used for local anesthetic classification.

Ester local anesthetics (aminoesters) are hydrolyzed by the cholinesterase enzyme in the plasma and liver.

Amide local anesthetics (aminoamides) undergo hepatic metabolism by microsomal enzymes. Compared with ester-linked anesthetics, the metabolism of amide-linked drugs is longer and involves more steps. Thus, toxicity resulting from accumulation of the drug and elevation in plasma levels is more likely to occur when amide agents are used (Campoy L. 2013).

The amino group is commonly a tertiary amine (NH2-R) and affects the degree of water solubility of the local anesthetic. Furthermore, this allows for molecular dissociation and combination with sodium channels (Tranquilli W.J. 2007).

Factors that can influence the quality of a regional anesthesia:

Many factors can influence the quality of regional anesthesia, including the local anesthetic dose, site of administration, additives such as hyaluronidase or epinephrine, pH adjustment and carbonation, temperature, baricity, mixtures of local anesthetics, and patient health status (Tranquilli W.J. 2007).

A greater dose (volume and/or concentration) can improve efficacy, decrease the delay of onset of action, and increase both the likelihood of successful anesthesia and its duration. Thus, a larger volume of local anesthetic will be able to produce a faster and denser block (Tranquilli W.J. 2007).

Concentration is also very important because a higher concentration of local anesthetic will produce a faster and more intense block. The onset is fast, usually within 3 to 5 minutes after administration, and the duration is based upon the kind of local anesthetic; thus, the practitioner can decide the duration of the block based on the necessity (Tranquilli W.J. 2007).

Additives:

Local anesthetics are usually mixed with additives. By adding a vasoconstrictor (e.g., epinephrine) to a local anesthetic agent, it is possible to decrease local perfusion and produce a delayed rate of vascular absorption of local anesthetic, and therefore increases the intensity and the duration of the anesthetic activity.

Epinephrine effects depend on the injection site and the local anesthetic, but it commonly reduces the potential toxicity of local anesthetics because it causes vasoconstriction and thus prevents higher blood concentrations.

Acidic epinephrine that is contained in local anesthetic solutions will be able to decrease the pH at the site of injection, depending on the pH and buffer demand of the injectate and the buffer capacity of the tissue.

Even hyaluronidase can be used. Hyaluronic acid is the tissue cement or ground substance of the interstitial tissues and influences the local anesthetic spread. It has been demonstrated that hyaluronidase improves the diffusion of local anesthetics, resulting in more effectiveness in retrobulbar-peribulbar anesthesia and extraocular muscle akinesia after retrobulbar injection (Tranquilli W.J. 2007).

How the pH affects the local anesthetic:

The pH of the local anesthetic solution affects the local distribution of the anesthetic and the properties of the local anesthetics (figure 1.1). Extracellular increase of bicarbonate also increases the cross-membrane pH gradient, the intracellular concentration of the ionized local anesthetic, and the local anesthetic effects. This is defined as the calculated ratio of the density of a solution to the density of CSF (Cerebro Spinal Fluid). One of the most important physical properties affecting the spread of local anesthetic solutions and level of analgesia achieved after performing an intrathecal administration of a local anesthetic is its density relative to the density of CSF at 37°C. Density is the weight of a unit volume of solution (grams per milliliter) at a specific temperature, whereas the specific gravity (SG) is the calculated ratio of the density of a solution (x) to the known density of water (y), (SG = xly). The density of a drug in solution cannot be determined from a simple formula because it depends on the physical state of that substance in solution (Tranquilli W.J. 2007).

	pKa	Ionization (%) (at pH 7.4)	Partition coefficient (lipid solubility)	Protein binding (%)	Relative potency
Esters					
Procaine	8.9	97	100	6	1
Chlorprocaine	8.7	95	810	–	4
Tetracaine	8.5	93	5822	94	16
Amides					
Lidocaine	7.9	76	366	64	4
Mepivacaine	7.6	61	130	77	2
Bupivacaine	8.1	83	3420	95	8–16
Levobupivacaine	8.1	83	3420	97	8–16
Ropivacaine	8.1	83	775	94	–

Figure 1.1: physicochemical properties of the local anesthetics (Campoy L. 2013).

pKa is the dissociation constant and it is the pH at which 50% of a drug is present in its ionized form and 50% is in its unionized form. The ability of a molecule to cross a cell membrane depends on both the molecular weight of the drug and its lipid solubility. As unionized molecules are more lipid soluble, they are the ones that will have the ability to cross nerve cell membranes. However, once inside the cell, it is the ionized local anesthetic molecule that binds to the sodium channel that determines the clinical effect (Campoy L. 2013). Ropivacaine has a pKa of 8.1 meaning that at that pH half of the drug is ionized.

The potency of the local anesthetics:

The potency of local anesthetics increases in vitro and in vivo with cooling in some instances but not in others. The inhibition of fibers (assessed by galvanic skin potentials) is marginally faster when ice-cold lidocaine (1%) is used compared with room-temperature lidocaine (1%) for median nerve blocks in volunteer. Cooling of lidocaine increases its pKa and the relative amount of the protonated (active) form within lipid, thereby potentiating the anesthetic effect. When a careful technique and an appropriate dose are used, local anesthetics are relatively free of harmful side effects. However, as with any pharmacological agents, local anesthetics may cause severe toxic reactions after unintentional intravenous administration, vascular absorption of an excessive dose (large volume or high concentration), or ingestion of topical local anesthetic preparations (Tranquilli W.J. 2007).

Local anesthetics toxicity:

Likewise other drugs, also local anesthetics can be harmful, but they are usually employed safely and without any consequence. Doses of local anesthetics, especially those for small dogs and cats, must always be carefully calculated and reduced especially with sick animals. For example, in healthy dogs and cats, the dose of ropivacaine should not exceed 4 and 3 mg/kg, respectively, to prevent toxicity. Repeated administration, higher dose than the recommended doses, and impaired elimination may all contribute to an increasing blood concentration of local anesthetics. Potential damage may also occur from chemical contamination of the local anesthetic solution, methemoglobinemia, allergic reactions, or neural ischemia produced by local pressure or hypotension.

Toxicity may be systemic and local (figure 1.2). The systemic toxicity of local anesthetics involves primarily alterations in both the CNS and the cardiovascular system (Tranquilli W.J. 2007).
CNS toxicity leads to convulsive activity by causing CNS depression with eventual respiratory arrest and cardiovascular collapse. CNS toxicity can occur with lower dosage compared to cardiovascular toxicity. In small animals, a low concentration of local anesthetics may produce sedation, whereas higher concentrations may produce seizures, probably because of selective depression of inhibitory fibers in the subcortical area (amygdala). Muscle twitching is usually the first sign of local anesthetic systemic toxicity observed in dogs and cats. More potent local anesthetics can consistently induce seizures even at lower blood concentrations and lower doses compared to less potent local anesthetics (Tranquilli W.J. 2007).
Local anesthetic cardiovascular toxicity may result from the direct electrophysiological and mechanical effects on the heart and the peripheral circulation, and from local anesthetic actions that affects the autonomic nervous system. Lower blood concentrations can result in CNS excitation, with increased arterial blood pressure, heart rate, pulmonary artery pressure, and cardiac output. With higher blood concentrations, the systemic effects are characterized by a decreased heart rate, arterial blood pressure, pulmonary artery pressure, and cardiac output.

	Relative potency for CNS toxicity	CVS:CNS ratio for toxicity
Esters		
Procaine	0.3	3.7
Chlorprocaine	0.3	3.7
Tetracaine	2.0	–
Amides		
Lidocaine	1.0	7.1
Mepivacaine	1.4	7.1
Bupivacaine	4.0	2.0
Levobupivacaine	2.9	2.0
Ropivacaine	2.9	2.0

Figure 1.2: relative potency and toxicity (Luis Campoy 2013)

Local anesthetics can induce the formation of methemoglobinemia as reported in two-hundred-forty-two episodes (40.1% published in year 2000 or after). The main drugs that caused this interaction are Prilocaine and Benzocaine (Guay J. 2009). Even ropivacaine can cause methemoglobinemia meaning that the anesthesiologist must be familiar with treating hypoxia (Cook A. 2021).

Methemoglobinemia (MHG) or increased concentration of methemoglobin (MHb) in the blood is defined as an altered state of hemoglobin whereby the ferrous form of iron (Fe 2 +) is oxidized to the ferric state (Fe 3 +), which increases the molecule's oxygen affinity for hemoglobin (as seen with MHG) and reduces oxygen release at tissues. In addition, oxidative denaturation of hemoglobin can cause the formation of Heinz-body, which can lead to erythrocyte lysis. MHG can cause hypoxia, cyanosis, or even death. It has been verified in humans that sometimes MHG is an adverse reaction not only due to the local anesthetics (Hummings D.R. 2011) but also to some antibiotics (e.g., dapsone) and anesthetic gases (e.g., nitric oxide) (Olson M.L. 1981). Consequently, the anesthetist needs to be familiar with this differential diagnosis for hypoxia given the use of drugs in the perioperative management (Cook A. 2021).

Another side effect is an allergic reaction to local anesthetics. Although this may occur, it is uncommon and often misdiagnosed after accidental intravenous injection of local anesthetics. Such reactions have been reported with amino-ester local anesthetics (e.g., procaine), particularly those that are metabolized directly to paraminobenzoic acid (PABA), a common allergen (Tranquilli W.J. 2007).

Ropivacaine:

The local anesthetic used in this study is Ropivacaine which is a long-lasting amide-type of local anesthetic. It belongs to N-achilpipecolil-xylidine, as Bupivacaine and Mepivacaine. These groups of pipecolic acid have an asymmetric carbon atom that gives the molecule chiral characteristics. They can present two enantiomers D and L, right shift and left, respectively. Ropivacaine was the first anesthetic made as a pure L anentiomer (figure 1.3).

Ropivacaine has a pKa of 8.07 similar to Bupivacaine but has a lipidic solubility inferior to Bupivacaine (Markham A. 1996), meaning that Ropivacaine has a lower affinity for Aβ fibers, a higher selectivity for Aδ fibers meaning a faster onset than Bupivacaine. Because Ropivacaine has a weaker bond with the extraneural fat and tissue, there should be a higher dosage of anesthetic to affect the nerves. Even a lower duration of epidural anesthesia with Ropivacaine can be justified with a minor liposolubility, due to the faster dissociation (Ackerman P.L. 1988). Epidural administration of Ropivacaine represents the main usage of this drug and at a lower concentration

(≤ 0.5%) produces a less intense block, which is helpful in a day hospital regimen where the patient must be able to walk even after the epidural anesthesia (e.g., after a cesarean). If there is a need for a more intense block a higher dosage can be used (Zaric D. 1996).

The selection of ropivacaine has been possible due to the identification of optically active isomers of the mepivacaine family, whose toxicology has been studied before its introduction on the market in 1996. It is even safer than Bupivacaine (Reutsch Y.A. 2001).

Ropivacaine has lower potential for inducing cardiovascular and CNS toxicity meaning that it is safer than other local anesthetics. At low concentrations (0.25–0.5%), ropivacaine has a relatively slow onset (Vloka A. 2004). For example, it has the onset between 15-22 minutes at a concentration of 0.35% for infraclavicular brachial plexus block (Kim H.J. 2021). When used in a peripheral nerve block it lasts between 5-8 hours. As a result of these favorable characteristics, Ropivacaine has gained wide acceptance and is frequently used for conduction and neuraxial anesthesia (Campoy L. 2013).

	Clinical use	Onset	Duration (hours)
Esters			
Procaine	Spinal (10%)	Fast	0.5–1
Chlorprocaine	PNB (2%)	Fast	0.5–1
	Epidural (2%)	Fast	0.5–1
Tetracaine	Topical (2%)	Fast	0.5–1
	Spinal (0.5%)	Fast	2–6
Amides			
Lidocaine	PNB (1–1.5%)	Fast	1–3
	Epidural (1.5–2%)	Fast	1–2
	Spinal (1.5–2%)	Fast	0.5–1
Mepivacaine	PNB (1–1.5%)	Fast	2–4
	Epidural (1.5–2%)	Fast	1–3
	Spinal (2–4%)	Fast	1–2
Bupivacaine/Levobupivacaine	PNB (0.25–0.5%)	Slow	4–12
	Epidural (0.5–0.75%)	Moderate	2–5
	Spinal (0.5–0.75%)	Fast	1–4
Ropivacaine	PNB (0.5–1%)	Slow	5–8
	Epidural (0.5–1%)	Moderate	2–6

PNB, peripheral nerve block.

Figure 1.3: Onset and duration of local anesthetics (Campoy L. 2013).

CHAPTER II: NERVES OF THE CHEST AND ABDOMEN AND MUSCLES OF THE TRUNK AND ABDOMEN

Thoracic nerves:

The thoracic nerves are 13 pairs in the dog, they retain the simplest segmental form of all the spinal nerves. Each pair of thoracic nerves has the same serial number as the vertebra that lies cranial to their intervertebral foramina of exit. Each thoracic nerve branches into a dorsal and a ventral branch (figure 2.1). The dorsal branch radiates into medial and lateral branches (Lahuta A.2013).

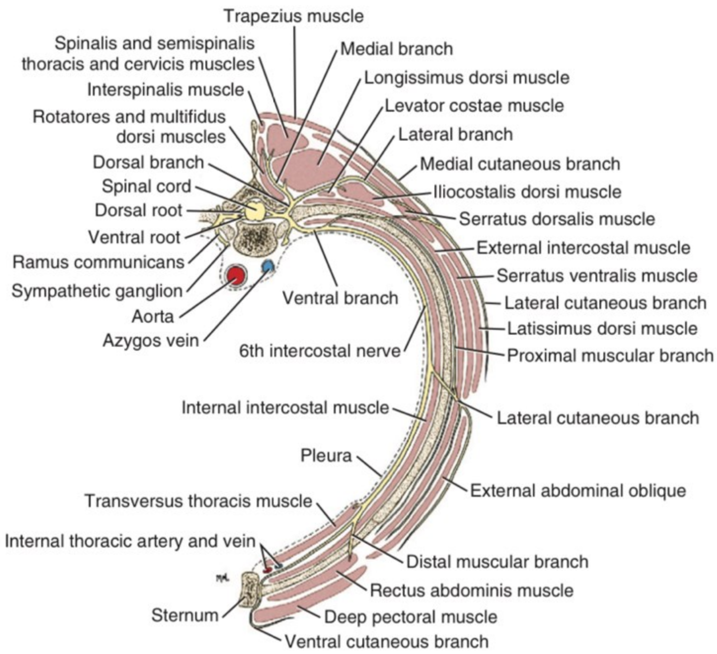


Figure 2.1: thorax section (Lahuta A.2013).

The lateral branches from the dorsal branches of the thoracic nerves run caudolaterally at a 45-degree angle to a sagittal plane. They run between the longissimus dorsi muscle medially and the iliocostal muscle laterally to reach the medial surfaces of the serratus dorsalis muscle. They usually perforate these segments along with the iliocostalis dorsi muscle. As these nerves cross the medial border of the iliocostalis dorsi muscle, they give off medial branches to it and the levator costae muscle segments. Except for the first thoracic nerve, longer lateral branches perforate the cutaneous trunci muscle to reach the skin, where they divide at the superficial fascia into a short medial cutaneous branch and a longer lateral cutaneous branch that both supply the skin of approximately the dorsal third of the thorax. These cutaneous branches do not communicate with adjacent branchlets and thus they establish a segmental innervation of the dorsal part of the thorax with considerable overlap between nerves (Bailey C.S. 1984).

The ventral branches of the thoracic nerves, except for most of the first and the thirteenth, are more commonly known as the intercostal nerves. These nerves have the following course: a proximal muscular branch leaves the dorsal (lateral) side of the intercostal nerve at 1 or 2 cm from its origin. Before it perforates the external intercostal muscle, it sends a long and narrow branch distally on the deep (medial) surface of the external intercostal muscle, which lies only a few millimeters caudal to the corresponding rib. It sends smaller branches to the external intercostal muscle throughout its length. Upon contact with the external intercostal muscle, a branch leaves the nerve that runs laterally and supplies the serratus dorsalis cranialis muscle. It does not radiate into any cutaneous branches.

A lateral branch of the intercostal nerve passes through the midlateral portion of the thoracic wall and runs distal in the superficial fascia with its homonymous artery. The lateral branch terminates by dividing into a middle muscular branch that supplies the thoracic parts of dorsal muscles of the abdominal wall and a lateral cutaneous branch that collectively supplies all the skin on the ventrolateral half of the thoracic wall except a narrow, longitudinal ventral section (Bailey C.S. 1984).

In the regions of the thoracic mammary glands, lateral mammary branches run from the distal portion of the lateral cutaneous branches and ramify under the skin of the mammary glands. Two distal muscular branches consist of a short nerve that enters the transversus thoracis muscle and a longer one that passes to the lateral side of the rib cage and enters the rectus abdominis. The ventral cutaneous branch is the terminal part of intercostal nerves T-2 through T-10 except T2, T9 and T10 that have no cutaneous branches.

In the superficial thoracic fascia, which lies on the medial portion of the deep pectoral muscle, the ventral cutaneous branch is closely bound to a larger ventral cutaneous artery. The aggregate of these nerves innervates a zone of skin approximately 5 cm wide that lies adjacent to the midventral line (Bailey C.S. 1984). The cutaneous area of the ventral cutaneous branch of T3 overlaps with the cutaneous area of the cutaneous branch of the ventral branch of C5 on the medial surface of the arm (Kitchell 1980). The terminal branches of the ventral cutaneous branches of T6 and T8 ramify in the skin covering the medial portions of the two thoracic mammary glands. They are called the medial mammary branches. The ventral extensions of the last two intercostal nerves leave the intercostal spaces medial to the costal arch and extend toward the linea alba on the superficial surface of the transversus abdominis muscle, which they supply before terminating in the rectus abdominis muscle. These nerves did not send ventral cutaneous branches to the skin (Bailey C.S. 1984). The intercostal nerves T11 and T12 have no ventral branches, while their lateral cutaneous branches are much longer, and their cutaneous areas extend ventral to reach the ventral midline (Bailey C.S. 1984). The Costo abdominal nerve is the ventral branch of the thirteenth thoracic nerve. It supplies a band of the abdominal wall that lies near the caudal border of the last rib and then continues tangentially to the last rib and costal arch in the abdominal wall. In its area of distribution, it lies cranial but parallel to the bands of the abdominal wall which is innervated by the ventral branches of the first three lumbar nerves. It divides into lateral and medial branches resembling those of the lumbar nerves lying caudal. Its lateral branch gives off a lateral cutaneous branch that has a cutaneous area that reaches the ventral midline (figure 2.2) (Bailey C.S. 1984) (Lahuta A. 2013).

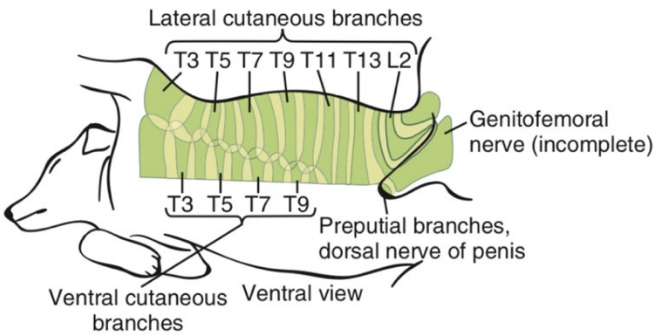


Figure 2.2: cutaneous innervation, ventral view (Bailey C.S. 1984)

Lumbar nerves:

The lumbar nerves (nn. lumbales) are seven pairs. Each pair has the same number, as its intervertebral foramen of exit and the vertebra that lies cranial to it. The first pairs' nerve roots of lumbar nerves lie essentially in the same transverse area as the foramina of exit of these nerves. As traced caudally, the segments of the spinal cord are shorter than the vertebral segments. As a result, the spinal cord ends more dorsal to the intervertebral disc between the sixth and the seventh lumbar vertebrae.

When the nerve exits, it divides upon leaving the intervertebral foramen into four primary branches: a small and variable meningeal branch, a small dorsal, a communicating branch, and a larger ventral branch. The actual length of the main trunk of each lumbar spinal nerve is only a few millimeters, and it lies lateral to the intervertebral foramen where it passes through.

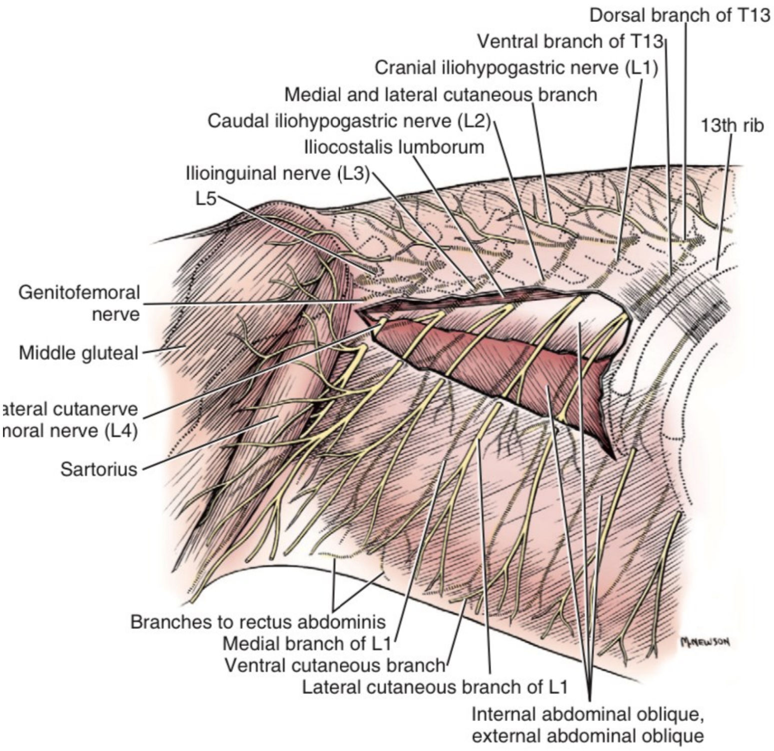


Figure 2.3: abdomen innervation (Lahuta A.2013)

The dorsal branches do not give off any dorsal cutaneous branches (Bailey C.S. 1984).

The lateral branches of the dorsal branches of the first three lumbar nerves run caudolaterally through the mm. longissimus and iliocostalis and perforate the iliocostalis muscle midlaterally in a segmental way (Lahuta A.2013).

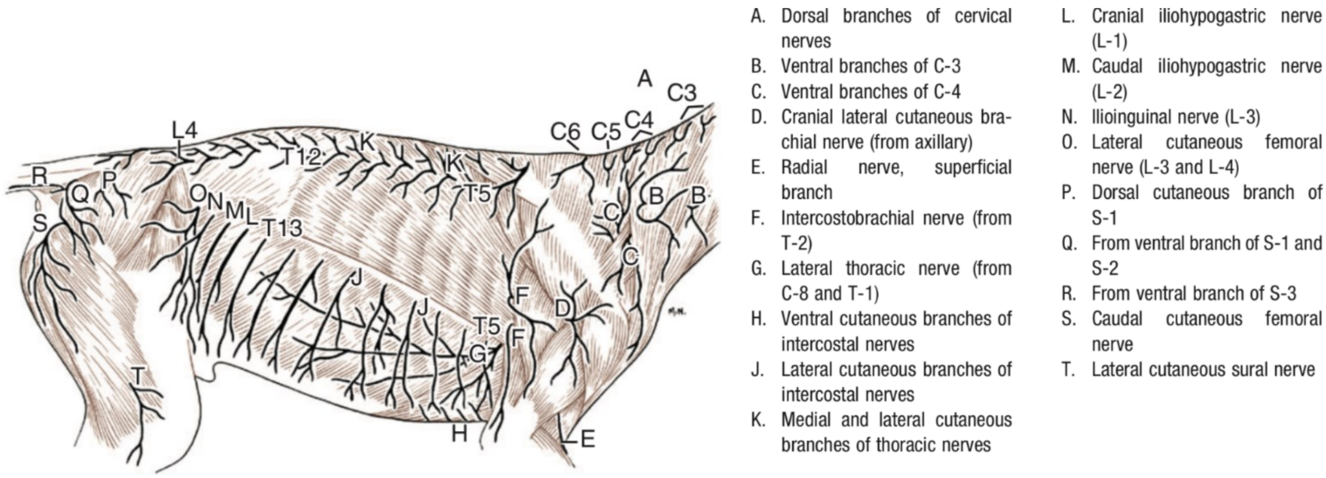


Figure 2.4: cutaneous innervation of the trunk and abdomen (Lahuta A. 2013)

The ventral branches of the seven pairs of lumbar nerves are variable. The first two lumbar nerves are usually not joined to each other or to adjacent nerves but run caudolaterally in the abdominal wall in series with the last several caudal thoracic nerves and therefore are not included in the lumbosacral plexus (Lahuta A. 2013).

The cranial and caudal iliohypogastric nerves represent the ventral branches of the first and second lumbar nerves, respectively both nerves give off medial branches that are muscular branches to the quadratus lumborum and psoas minor muscles. After passing between the two segments of the quadratus lumborum, the cranial iliohypogastric nerve lies in the subserous endothoracic fascia at its origin. Then it passes into the subserous transversalis fascia of the abdomen by passing dorsally to the lumbocostal arch. It gives branches to the serosa and to the segments of the quadratus lumborum muscle, against which it lies. After passing through the aponeurosis of origin of the transversus abdominis muscle, it runs between two fleshy bundles of the transversus abdominis muscle which arises from a narrow aponeurosis that attaches to the ends of the transverse processes of the lumbar vertebrae (Lahuta A. 2013)

Shortly after entering the fascia that separates the transverse abdominal muscle from the internal abdominal oblique muscle, the cranial iliohypogastric nerve divides into lateral and medial branches. The lateral branch passes through the internal abdominal oblique to run in the septum between the two abdominal oblique muscles. In its course ventrocaudally, it innervates these muscles, and near the middle of the abdomen it perforates the external abdominal oblique muscle to become subcutaneous as the lateral cutaneous branches. It is also accompanied by a branch of the cranial abdominal artery and vein. The lateral cutaneous branch is ventrolaterally distributed to the skin and later crosses the junction of the cranial and middle thirds of the abdomen caudal to the ribs. Its cutaneous area extends ventrally to the ventral midline (Spurgeon T.L. 1986).

The medial branch lies closely to the lateral surface of the transversus abdominis muscle, where it appears in series with the last five thoracic and L1 and L2 nerves. It supplies a band of the transversus abdominis muscle and peritoneum along its course. It ends in the first segment of the rectus abdominis muscle and peritoneum dorsal to it. It has no ventral cutaneous branch (Bailey C.S. 1984).

The ventral branch of the second lumbar nerve is the caudal iliohypogastric nerve. This nerve is in all respects like the first lumbar nerve except that it supplies the abdominal wall caudal to it and appears at the lateral border of the hypaxial musculature after passing between the quadratus lumborum and iliopsoas muscles. Occasionally, one of the iliohypogastric nerves is double. The lateral cutaneous branch of the caudal iliohypogastric nerve is similar to that of the cranial iliohypogastric except that it does not reach as far ventrally. The caudal iliohypogastric nerve also has no ventral cutaneous branch (Bailey C.S. 1984) (Lahuta A. 2013).

Muscles of the trunk:

Trunk muscles have a few very important functions; they contribute to the protection of the thoracic viscera, and they assist essential body activities such as breathing. The stratification of these muscles is composed as follows starting from the most external muscle (figure 2.5):

- longissimus thoracis muscle:
- serratus ventralis muscle:
- external intercostal muscles:
- internal intercostal muscles:
- transversus thoracis muscle.

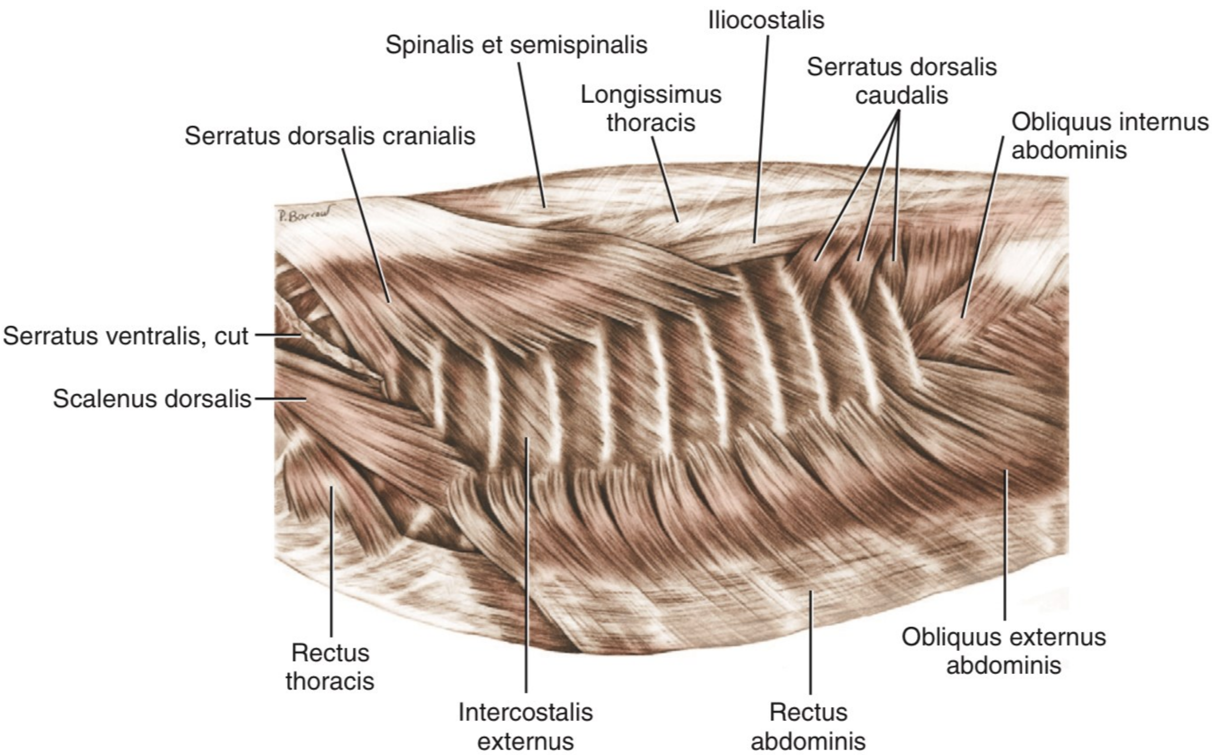


Figure 2.5: Superficial muscle of the thoracic cage, lateral aspect (m. serratus ventralis has been removed) (Lahuta A. 2013).

Longissimus thoracis muscle:

This muscle has serrations that run to the caudal borders of the ribs with broad tendinous leaves. Each tendinous leaf separates into a medial and a lateral terminal tendon with thicker edges. The dorsal branches of the thoracic nerves pass between these tendons. The medial tendons of these ventral serrations end on the accessory processes from the thirteenth to the sixth thoracic vertebrae. Because these accessory processes are lacking from the fifth to the first thoracic vertebrae, the medial tendons insert on the caudal ends of the transverse processes. The lateral tendons of the longissimus thoracis muscle insert from the sixth to the thirteenth ribs, where they attach medially to the attachment of the iliocostalis muscle on the edge of a flat corrugation adjacent to the costal tubercle. The muscle becomes narrower cranial to the sixth rib so that its tendons appear undivided. The terminal tendons end on the costal tubercles of the fifth to first rib immediately lateral to the costotransverse joint. Occasionally, further divisions of the terminal tendon insert on the transverse processes of the sixth and fifth cervical vertebrae, where they fuse with serrations of the longissimus cervicis muscle (Liebich H.G. 2020).

Dorsal serrate muscle:

Dorsal serrate muscles origin from an aponeurosis at the spino-costo-transversal fascia and the supraspinal ligament, and from the caudal part of the thoracolumbar fascia. They attach by a series of individual digitations to the ribs, and they are lateral to the iliocostal muscles. Based on the direction of their fibers, they can be divided respectively into a cranial and a caudal portion.

The cranial portion caudoventrally pulls the ribs and rotates them in an outward motion during contraction, thus acting as an inspiratory muscle. In dogs, it originates from the first six to eight thoracic vertebrae and the thoracolumbar fascia and inserts with single slips to the cranial and lateral aspect of the third to tenth ribs (Liebich H.G. 2020).

Intercostal muscles:

The intercostal muscles fill the spaces between the ribs, the deeper internal intercostal muscles, and the more superficial external intercostal muscles. The fibers of the internal intercostal muscles run from the cranial margin of one rib to the caudal rim of the preceding rib in a cranioventral direction. These muscles lie in a lateral direction to the intercostal nerve and assist expiration. The fibers of the external intercostal muscles are perpendicular to the ones of the internal layer, thus bridging the individual intercostal spaces in a caudoventral direction and acting as inspiratory muscles. The external intercostal muscles fill the intercostal spaces from the vertebral column to the costochondral junctions, but they do not extend as far as the sternum (Liebich H.G. 2020).

The Trasversus thoracis muscle:

It is a flat, fleshy muscle, lying on the dorsal surfaces of the sternum and adjacent costal cartilages. It forms a continuous triangular leaf that covers the second to the eighth costal cartilages. Its fibers arise from a narrow aponeurosis, on the dorsolateral surface of the sternum, from the second sternebra to the caudal end of the xiphoid process. These fibers end with indistinct segmentations on the second to the seventh costal cartilages, somewhat ventrally to the costochondral articulation. The muscle contributes to expiration (Lahuta A. 2013).

Muscles of the abdomen:

The abdominal wall consists of sheets of muscle that maintain abdominal integrity, provide support and strength for movements such as jumping and twisting and, when tense, are rigid enough to protect the abdominal content. There are the following four abdominal muscles, which derive their names from their position and structure, starting from the most external muscle:

- external oblique abdominal muscle
- internal oblique abdominal muscle
- transverse abdominal muscle
- straight abdominis muscle

<u>The external oblique abdominal muscle:</u>

It is the most superficial abdominal muscle and is only covered by the abdominal part of the cutaneous muscle. It has a wide origin having a series of digitations from the lateral surfaces of the ribs caudal to the fourth or fifth rib. The more cranial digitations alternate with those of the ventral serrate muscles. Its origin curves caudo-dorsally until it reaches the end of the thirteenth rib, where it fuses with the thoracolumbar fascia.

The external oblique abdominal muscle can be divided in a larger and smaller portion: the thoracic portion is the largest and it arises from the lateral surface of the thorax whereas the lumbar portion is smaller and originates from the last rib and the thoracolumbar fascia (Liebich H.G. 2020).

The muscle fibers of the ventral part of the muscle split caudoventrally, but the dorsal bundles follow a more horizontal course. The fleshy part of the muscle is continued as a broad aponeurosis form at the ventral quarter of the abdominal wall. This large aponeurosis then finally fuses ventrally with the aponeurosis of the internal oblique abdominal muscle, forming the external leaf of the sheath of the straight abdominal muscle (rectus sheath, vagina recti abdominis muscle) where it inserts to the linea alba and the prepubic ligament with the abdominal tendon and to the inguinal ligament with the pelvic tendon (Liebich H.G. 2020).

In dogs, the abdominal tendon is fused with the deep fascia of the trunk on the outside and with the aponeurosis of the internal oblique abdominal muscle on the inside, meaning it forms the external leaf of the rectus sheath. Then, the sheath blends with the transverse tendinous intersections of the straight abdominis muscle. The lateral crus of the pelvic tendon unites with the medial crus in the caudal angle of the superficial inguinal ring (Liebich H.G. 2020).

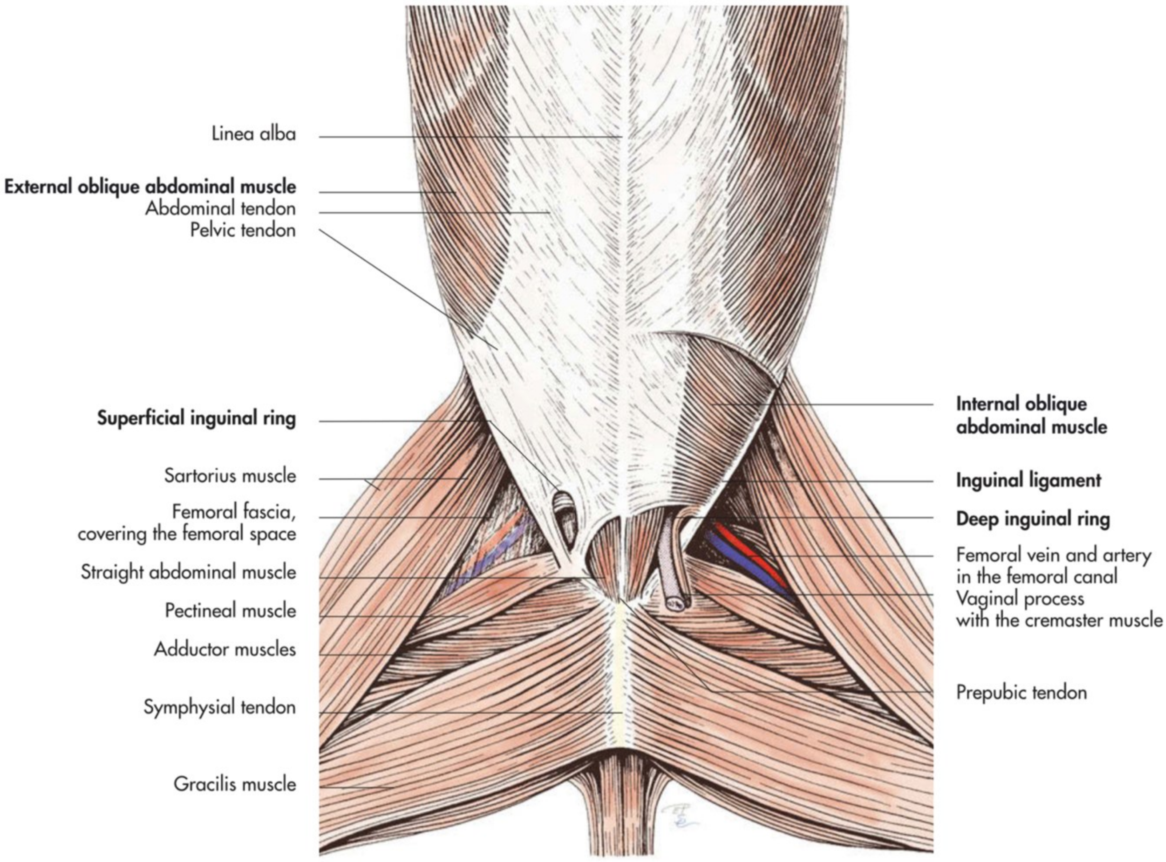


Figure 2.6: muscles of the abdomen ventral view (Liebich H.G. 2020).

<u>The internal oblique abdominal muscle:</u>

It lies deeper than the external oblique abdominal muscle. It originates from the tuber-coxae, which is the proximal part of the inguinal ligament and it stems from the transverse processes of the lumbar vertebrae and the thoracolumbar fascia. Then it fans out cranioventrally and its fibers are orientated at a right angle respective to the ones of the external oblique abdominal muscle. Its muscular part becomes a broader aponeurosis at the level of the lateral border of the straight abdominis muscle. It unites with the aponeurosis of the external oblique abdominal muscle, and it forms the external leaf of the rectus sheath, which blends at the linea alba with that of the opposite side (Liebich H.G. 2020).

The transverse abdominal muscle:

The transverse abdominal muscle is the smallest of the four abdominal muscles that can be observed with the ultrasound probe, and it lies deep to the others. It is a muscular sheet of parallel bundles of fibers, which originates cranially from the inner face of the costal cartilages of the twelfth and thirteenth ribs in the dog and caudally from the transverse processes of the lumbar vertebrae. Its caudal border extends until the level of the coxal tuberosity. Its muscular part continues as an aponeurosis starting from the level of the lateral border of the rectus abdominis muscle. This aponeurosis constitutes the internal part of the rectus sheath. Since the transverse abdominal muscle does not extend beyond the level of the tuber coxae, the internal leaf of the rectus sheath is absent in the pelvic region. Indeed, the aponeurosis does not extend this far as the inguinal canal (Liebich H.G. 2020).

The straight abdominis muscle:

The straight abdominis (or abdominal) muscle is confined to the ventral aspect of the abdominal wall and does not form an aponeurosis unlike the other abdominal muscles. The straight abdominal muscle arises from the costal cartilages of the true ribs and the adjacent parts of the sternum and inserts into the prepubic tendon. The fibers of the muscles are directed longitudinally on both sides of the linea alba. Transverse bands of fibrous tissue, called tendinous intersections, extend across the muscle (Liebich H.G. 2020).

CHAPTER III: LOCOREGIONAL ANESTHESIA:

Peripheral nerve block:

In the following study were used neuraxial loco regional techniques. Nerve plexus block anesthesia regional anesthesia is the injection of a local anesthetic solution in the vicinity of a peripheral nerve to temporarily block sensory and/or motor functions and it is used to control pain both intraoperative and postoperative. There are many peripheral nerves that can be blocked, depending on the region of interest in the body. There is two ways of administering the local anesthetic in a safe way.

The first is via nerve stimulators, a piece of equipment used to generate an electric field in the tissues immediately surrounding a target nerve. If the nerve carries motor fibers, the electric current that is induced by the nerve stimulator will result in depolarization of these nerves, and consequently, the muscles that are served by that nerve will contract. The visible contractions are used to confirm the correct placement of the needle.

The second is ultrasound guidance and it has become popular in modern medicine, and to perform. The advantage of ultrasound guidance is that the variation in individual patient anatomy no longer negatively affects block success rates. As target nerves can be "seen" via ultrasound they can more effectively be located with a needle tip prior to injection of the local anesthetic solution. It is considered the most accurate technique, so has a longer block duration (Campoy L. 2013).
When Orebaugh studied the use of ultrasound guidance versus nerve stimulation for peripheral nerve blockade performed by anesthesia residents, they found that ultrasound guidance resulted faster and there were fewer inadvertent vascular punctures (Orebaugh S.L. 2007) Both techniques can be used together in certain types of blocks (Campoy L.2013).

TAP block:

Ultrasound guidance has been introduced in the field of regional anesthesia to reduce the subjectivity and the risks of performing nerve blocks blindly (Marhofer P. 2005). However, ultrasound image acquisition and interpretation can still be subjective, and the anesthetist should have knowledge of the relevant anatomy and an understanding of the basic physics of ultrasound to correctly interpret the images that are obtained (Romano M. 2020). The quality of the ultrasound can have an impact as well.

Failure to adequately control postoperative acute pain can have several unwanted physiological and psychosocial consequences for the patient including dissatisfaction, myocardial problems, prolonged hospital stay, and even the potential progression to chronic pain. Pain provoked by abdominal surgery can be very severe and current postoperative analgesic regimens rely heavily on systemic opioid analgesics. However, opioids are associated with several undesirable side effects including nausea, vomiting, constipation, respiratory depression, and many others, thus safer alternatives need to be evaluated (Taylor R. 2013).

Ultrasound-guided TAP block was originally described in dog cadavers using a 1 ml/kg single injection at the midpoint between the last rib and the iliac crest and 5 cm lateral to midline injected in twenty hemi-abdominal walls (Schroeder L.B.C. 2011) There have been contradictory reports on whether larger volumes result in wider spread in Bruggink and Zoff's study. Bruggink's study used Bilateral TAP blocks using ultrasound guidance and it was performed in 20 Beagle cadavers. The dermatomal spread (number of ventral nerve roots saturated by injected solution) was volume dependent ($P = .026$, Kruskal Wallis): 2.9 ± 0.74 nerve roots for 0.25 mL/kg; 3.4 ± 1.1 for 0.5 mL/kg; 4.0 ± 0.67 for 0.75 mL/kg; and 4.2 ± 1.2 for 1 mL/kg meaning that the volume of injected local anesthetic solution significantly affects cranial to caudal spread (Bruggink S.M. 2012). In Zoff's study where a comparison was made, via CT imaging, the spread of different volumes diluted iodinated contrast medium in the Trasversus abdominis muscle plane block in dog cadavers where the difference was mainly found in the trasverse spread, not dorso-ventral or cranio-caudal, with two different volumes 1ml/kg and 0.5ml/kg in 26 cadavers. A significant difference between groups was found in the spread of the contrast in the transverse plane (depth) with a difference of 0.029 cm/kg. The methods used in this study could not identify the nerve roots, although the localization of the injectate was at the level of L3 to L5, over two to three intervertebral spaces. This would have resulted in a likely block of ventral roots L2 to L4, which would provide analgesia for caudal abdominal surgeries. The abdomens were scanned via CT within five minutes after the injection of the diluted contrast. (Zoff A. 2017). Alternative approaches with two sites of injection have been introduced, where the sites are one caudal to the last rib and the other cranial to the iliac crest, and they en used to provide successful analgesia in dogs (Portela D.A. 2014) (Portela D.A. 2018). Then it was described that a subcostal oblique technique in dog cadavers showed a wider cranial spread than the traditional approach (Drożdżyńska M. 2017). Anatomical variations in the spinal thoracolumbar nerve branches that run within the TAP, and they were observed in mongrel dogs. These anatomical variations should be considered when planning locoregional anesthetic protocols related to the abdominal wall, abdominal skin, abdominal mammary glands, and prepuce (Castañeda-Herrera 2017).

The decision of the location of the injection of the local anesthetic is critical to block the peripheral nerve signaling within the abdomen. Various injection points have been shown to disperse anesthetics differently and thus can affect both the intensity and duration of analgesia. Spinal nerves denoted T7 to T11 emerge from the intercostal space and then run along the neurovascular plane between the internal oblique and the transversus abdominis muscles. The subcostal nerve (T12) and the ilioinguinal and iliohypogastric nerves (L1) also travel in the plane between the two muscles. Nerves T8–10 are targeted with local anesthetics so that it can potentially allow for the blockade of pain signals both above and below the umbilicus, thus making this technique particularly useful in the postoperative setting of laparoscopic colorectal resections and bowel surgery, laparoscopic cholecystectomy, renal transplant surgery, appendicectomy, inguinal hernia repair, abdominoplasticity, and gynecological surgery (Taylor R. 2013). In veterinary medicine, it can be used for mastectomy of the inguinal mammary glands, and for total mastectomy. A previous study used the TAP block associated with a thorax block such as intercostal blocks (Portela D.A. 2014).

Preparation of the patient:

Firstly, the patient must be put under sedation or light general anesthesia. The positioning is in lateral recumbency, with the side to be blocked uppermost. Then the hair is clipped in the abdominal region and the skin must be prepared with aseptic solution. To maintain sterility, a sterile cover must be applied to the probe and the depth can be adjusted to 1,5-3cm (Portela D.A. 2017).

Subcostal approach:

Where the anatomical landmark is the caudal border of the last rib and the xiphoid cartilage.

The probe is positioned perpendicular to the abdominal wall and directed to the costal margin; the needle is inserted near the xiphoid process and the local anesthetic is injected between the rectus and the Trasversus muscle (Hebbard 2008).

The first study conducted in dogs was Drożdżyńska a study on 9 adult beagle cadavers where the ultrasound-guided subcostal oblique TAP block provided adequate staining of the sensory innervation.

This technique may be suitable for use in the treatment of somatic pain associated with procedures performed in the cranial abdomen, such as liver surgeries (lobectomy, portosystemic shunt occlusion, cholecystectomy), gastrotomy and splenectomy (Drożdżyńska M. 2017).

Paracostal approach:

The anatomical landmark is the caudal border of the last rib.

For the paracostal approach the probe is positioned caudally and parallel to the last rib at the corresponding height of L2-L3 and dorsal to the midaxillary line (Portela P.E. 2017).

The paracostal does not provide a broader distribution especially cranially than the subcostal approach. (Romano M. 2020)

Umbilical approach:

The anatomical landmarks are the iliac crest and the umbilicus.

The probe is positioned cranially to the iliac crest at the height of the intervertebral space of L5 to L6 at the level of the umbilicus and dorsal to the midaxillary line (Portela P.E. 2017).

What you see via ultrasound:

The identification via ultrasound is as follows: for starter, the recognition of the Trasversus abdominis and internal and external oblique abdominal muscles and the parietal peritoneum is fundamental, the straight abdominal muscle cannot be seen due to the positioning of the probe, which lies more dorsally than the muscle. Afterward, the needle is introduced in plane and advanced until the tip is located between the internal oblique abdominal and the Trasversus abdominis muscles. Once the tip reaches the desired location, inject a small amount of local anesthetic volume to confirm the right placement. If the injection is intramuscular, slightly withdraw the needle and redirect it towards the target plane. Subsequently the Trasversus abdominis muscle should separate from the internal oblique abdominis muscle (Portela P.E. 2017) (figure 3.1).

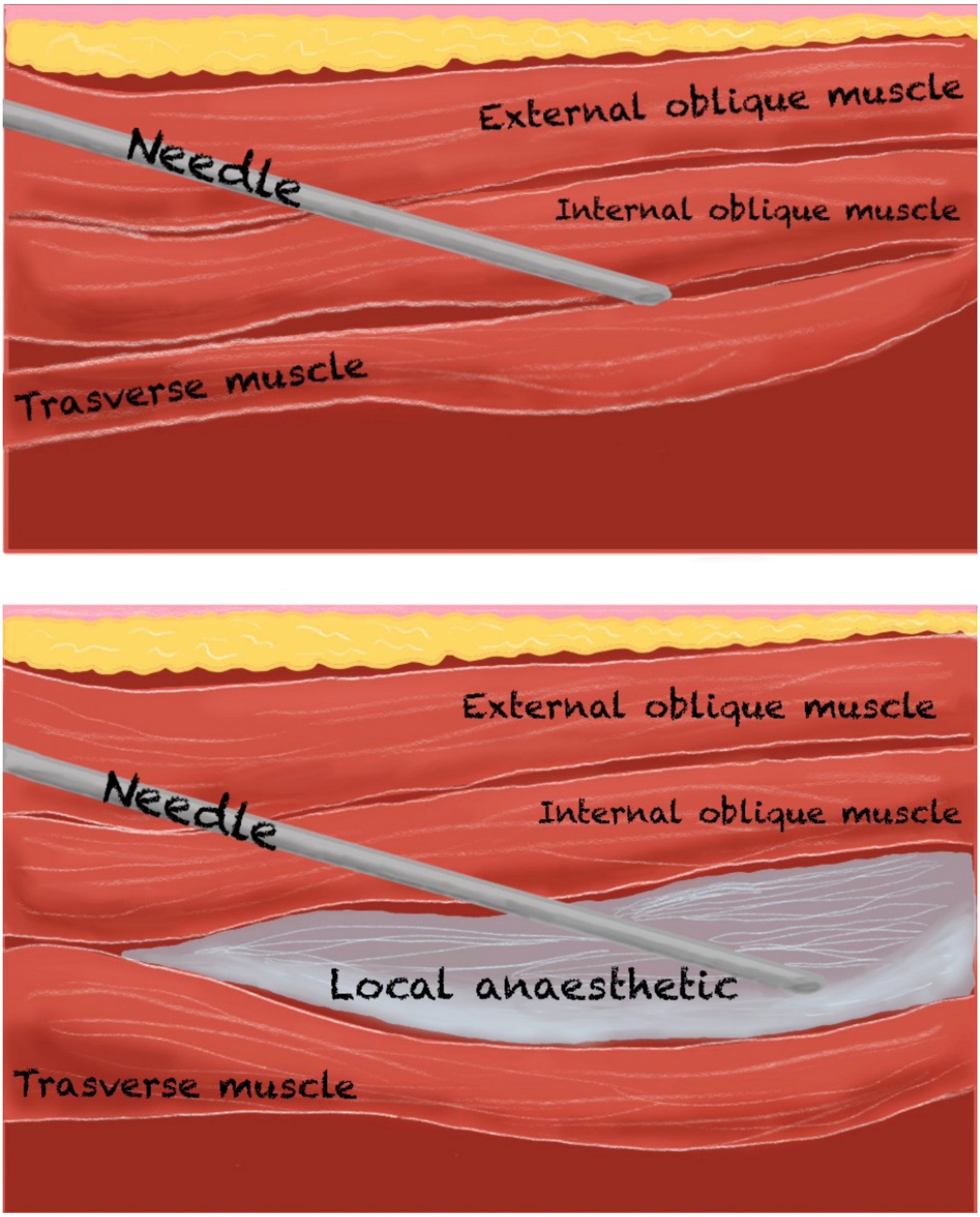


Figure 3.1: Transverse abdominis plane block illustration of the procedure

Spread and volumes:

Ultrasound-guided TAP block was originally described by Schroeder in dog cadavers using a 1 ml/kg single injection at the midpoint between the last rib and the iliac crest and 5 cm lateral to midline injected in twenty hemi-abdominal walls. Segmental branches of T11, T12, T13, L1, L2, and L3 were adequately stained in 20%, 60%, 100%, 100%, 90%, and 30%. In the study of (Schroeder L.B.C. 2011). The injectate volume of 10.0 mL used by Drozdzynska was based on the only veterinary study known to have been published previously (Schroeder L.B.C. 2011), which served as a comparator for the present results. However, in a clinical context, decisions on the volume to be injected will be influenced by two factors: toxic dose, and the final concentration of the local anesthetic solution. The first consideration refers to the need to not exceed the toxic dose, and the second to the stipulation that the local anesthetic should not be diluted below its minimum effective concentration because this may result in failure to achieve a sensory block.

Further clinical studies in veterinary anesthesia are required to determine the peak plasma concentration of local anesthetics following their administration for TAP block, and the minimum dose required to achieve a satisfactory analgesia. The distribution of the dye in cadavers may not exactly reflect the final distribution of local anesthetics in clinical cases. (Carney J. 2008) found that, in humans, the spread of local anesthetics within the fascia is time dependent. Although this information is not applicable to a study using cadavers, it may have a significant impact on the clinical efficacy of the block with reference to the time that elapses between the performance of the block and the start of the surgical procedure.

The kind of solution affects the spread as demonstrated by De Miguel Garcia in “Effect of contrast and local anesthetic on dye spread following transversus abdominis plane injection in dog cadavers“ where the spread in a group where the author used a mixture of blue methylene and Bupivacaine, although not statistically different, was smaller than the group where only blue methylene was used by almost 10 mm (Garcia D.M. 2020).

The Subcostal’s approach spread:

This technique has the most cranial spread of the dye reached T9 nerve, which was successfully stained in 72% of cases. T9, T10, T11, T12, and T13 were successfully stained in 72% 95%, 100%, 95%, and 61% of cases, respectively. The L1 and L2 nerves were successfully stained in 33% and 11% of cases, respectively. These results are due to the lower volume, this study used 10 ml in nine beagle cadavers ranging in weight from 11-15 kg meaning that the volume ranges from 0.6 to 0.9 ml/kg (Drożdżyńska M. 2017).

The paracostal approach:

Stained the first lumbar (L1) spinal nerve in 100% of injections and ninth thoracic (T9, T10, T11, T12, T13, L2) were stained in 0%, 0%, 37.5%, 62.5%, 87.5% and 87.5% of injections, using 0.25 ml/kg of methylane blue.

The Umbilical approach's spread

Firstly, in the study by Schroeder (Schroeder L.B.C. 2011), the most cranial spread of dye extended to the level of T11 which was stained in only 20% of cases (with 10 ml of volume in ten Beagle cadavers ranging weight between 10 and 12.2 kg meaning a dosage of 1 to 0.8ml/kg). Segmental branches of (T11, T12, T13, L1, L2, and L3) were adequately stained in 20%, 60%, 100%, 100%, 90%, and 30% of injections, respectively (Schroeder L.B.C. 2011).

The first study that compared using different types of volume is the study of Bruggink, that used 20 Beagle cadavers. The Dermatomal spread (number of ventral nerve roots saturated by injected solution) was volume dependent (P =.026, Kruskal Wallis): 2.9 ± 0.74 nerve roots for 0.25 mL/kg; 3.4 ± 1.1 for 0.5mL/kg; 4.0 ± 0.67 for 0.75 mL/kg; and 4.2 ± 1.2 for 1 mL/kg. (Bruggink S.M. 2012).

Freitag's study compared different volumes in the umbilical approach and observed how it affected the spread Results, suggest that a single-injection TAP block, using 0.3 ml/kg, stains a comparable number of nerve branches as higher volumes (of 0.6 and 1 ml/kg) or two-point injection. Despite the volume or technique, consistent staining of the innervation of the caudal abdomen (L1-L3) was observed (Freitag A.V. 2021).

Several factors may have contributed to the differences between the two studies. Dorsal positioning and direction of the needle during injection in the present study could have favored a dorso-ventral spread, which would be less clinically relevant than craniocaudal spread. In addition, spread of a fixed volume of injectate may be different in fresh and thawed cadavers. In the present study, fresh dog cadavers were chosen to avoid the impact of autolysis on distribution and times between injections, and dissections were standardized. (Freitag A.V. 2021).

Serratus Block:

The serratus plane block was introduced in human medicine for mastectomy a very painful surgical procedure, which is also very common, and usually, it's associated with other types of blocks, depending on the incision site (P. E. Portela 2017).

As explained by Freitag in "ultrasound-guided superficial serratus plane block in dog cadavers: an anatomical evaluation and volume dispersion study" the spread of the local anesthetic stains the cutaneous branches of T2-T5 (Freitag A.V. 2019).

When to use this type of block:

Thoracic injuries and surgery are associated with high levels of pain that can be challenging to treat (Beswick et al. 2016). The canine thoracic wall sensory innervation is mainly by the lateral cutaneous branches of the thoracic spinal nerves T2-T11 (Bailey CS 1984). Local anesthesia, including intercostal nerve block, segmental thoracic epidural anesthesia, and thoracic paravertebral block, is used to provide analgesia for surgeries such as thoracotomy, thoracic wall mass removals, pain control in rib fractures, or even thoracic mastectomy (D. A. Portela 2014) (Portela DA 2018) (Corona D 2018). Due to the innervation of the thoracic wall, this type of local anesthesia affects the nerves that innervate the most superficial part of the thoracic wall. There are two types of serratus plane blocks: superficial and deep. The approach where the needle is inserted between the fourth and fifth rib for superficial serratus plane (SSP) block in human cadavers demonstrated the spread of methylene blue over the lateral cutaneous branches of the T2-T5 intercostal nerves, with some variable spread which was up to T6, the long thoracic nerve and, occasionally, the thoracodorsal nerve (Freitag A.V. 2019).

The superficial serratus plane block the needle tip reaches the fascial plane between the serratus ventralis thoracis and latissimus dorsi muscles.

in the deep serratus plane block the needle tip reaches the fascial plane between the serratus ventralis and the external intercostal muscle.

The choice of the superficial plane rather than the deep plane injection was influenced by a study reporting a larger blockade area and longer duration of the block from a superficial plane injection This regional anesthetic technique may be suitable for peri-operative analgesia for several surgical procedures. These include any surgery that involves incision on the anterolateral chest wall, such as chest drain insertion, reconstructive breast surgery and cosmetic breast surgery. The innervation of the abdominal wall is derived from the thoracic level of T6–L1, so blockade of these sensory dermatomes in the thoracic region should provide some degree of analgesic efficacy, particularly in upper abdominal wall incisions. (Blanco et al. 2013), and the positions of the lateral cutaneous nerve branches seen in the formaldehyde preserved cadaver, this is Freitag's study made to establish the optimal landmarks for a superficial serratus plane (SSP) block and evaluate ropivacaine-methylene blue solution dispersion with three volumes of injection. (Freitag A.V. 2019).

The thoracic wall muscles identified in the formalinized cadaver were the cutaneous trunci, latissimus dorsi, external abdominal oblique, serratus ventralis thoracis, scalenus, serratus dorsalis cranialis and external intercostal. The nerves identified in the SSP included the lateral cutaneous branches of intercostal nerves, intercostobrachial nerves and long thoracic nerve. 0.3, 0.6 and 1.0 mL/kg respectively, with no significant difference among them.

Complications are due to the needle that might puncture the pleura causing a pneumothorax or worse the lung creating a lung puncture both of which have been described in human medicine although rare. There is also dural puncture, intrathecal injection, hypotension, bilateral blockade, intravascular injection, infection, hematoma, neural fascicle damage, intrapleural injection, and block failure (Finucane B.T. 2007).

<u>Preparation of the patient:</u>

Firstly, the patient must be put under sedation or light general anesthesia. The positioning is in lateral recumbency, with the side to be blocked uppermost. Then the hair is clipped in the thoracic region and the skin must be prepared with aseptic solution. To maintain sterility a sterile cover must be applied to the probe and the depth can be adjusted to 1,5-3cm. (Portela P.E. 2017).

The landmarks for the serratus plane block are:

- the caudal border of the scapula after having pulled the thoracic limb forward
- the fourth intercostal space at the level of the junction between the proximal and middle thirds (Portela P.E. 2017).

What you see via ultrasound:

After placing the sterile cover over the transducer and adjusting the reading depth to the patient's anatomy, to enhance the acoustic coupling.

The thoracic limb must be pulled forward and then the transducer is placed until a clear image of the ribs and fascial plane between the serratus ventralis and the external intercostal muscle is obtained.

Via ultrasound the following muscles can be identified: the cutaneous dorsal muscle, lungissimus dorsalis, serratus ventralis, the intercostal muscles and the pleura, ribs can even be identified since they reject the sound meaning it is viewed as hypoechoic as illustrated in (figure 3.2).

The needle is introduced in-plane at the caudal border of the transducer and advanced it cranially. Once the tip of the needle is located in the interfascia plane, inject a small amount of local anesthetic to confirm the correct position of the needle tip, which should result in the separation of the muscular planes. If the injection occurs in the intramuscular space, withdraw the needle slightly and redirect it towards the correct target plane. After confirming the needle tip is extravascular, slowly inject the total volume of injectate calculated (Portela P.E.2017).

Spread and volume:

The solution dispersion of this technique covers T1-T6 dermatomes in at least 50% of the hemithoraces of each group. Dispersion up to T9 was observed in some hemithoraces. T1 and T2 dispersion is more cranial than the results reported in humans, which start at T3 (Biswas A. 2018).

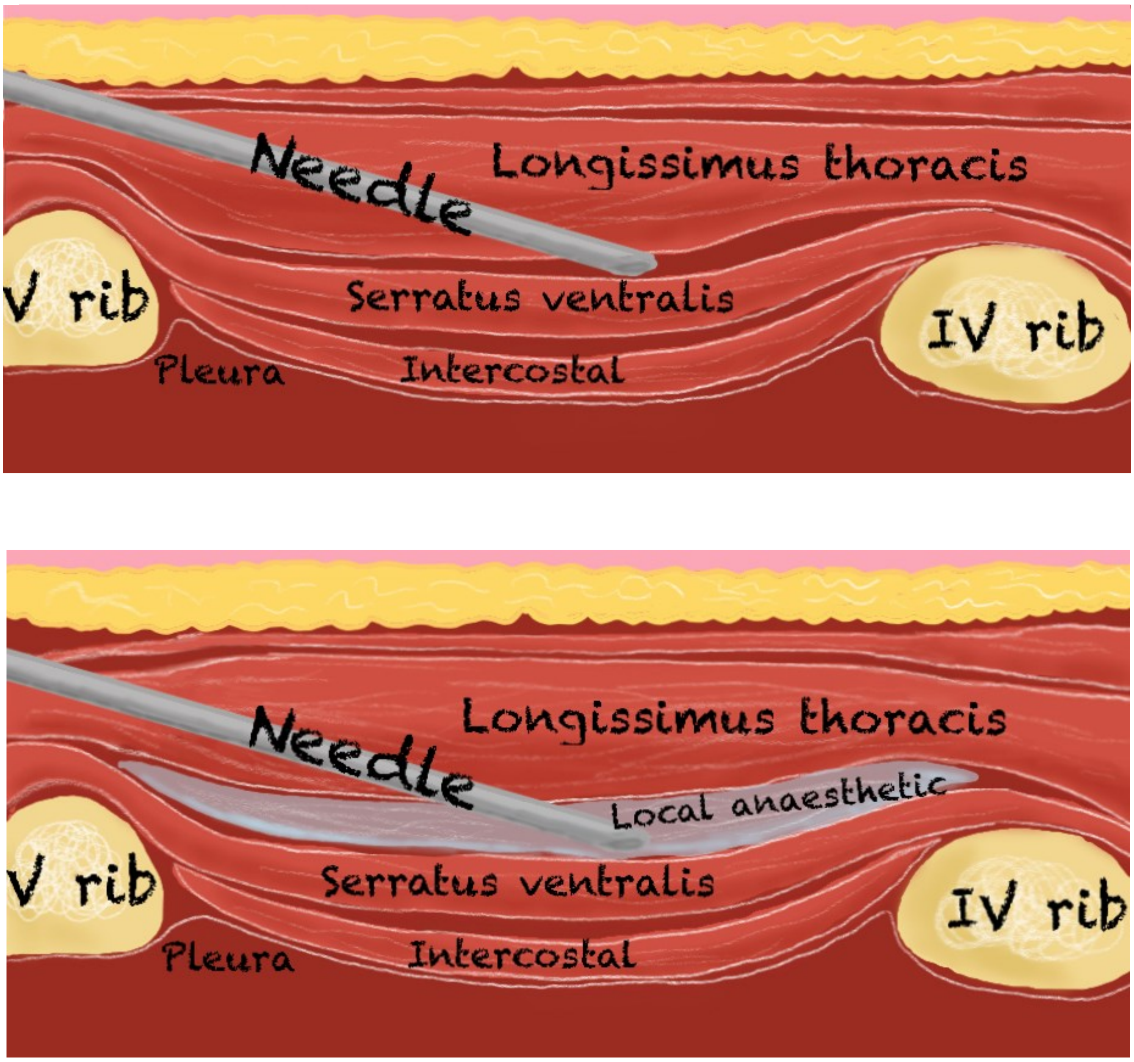


Figure 3.2: serratus plane block illustration of the procedure

CHAPTER IV: MASTECTOMY

Mastectomy is considered, in dogs, the gold standard for treating mammary tumors (Sleeckx N., 2011). The canine mammary glands are divided into two mammary lines that start from the trunk and extend until the lower abdomen. There are usually 5 pairs of mammary glands, but this can change and generally there are between 4 and 6 pairs (Lahuta 2013).

The surgical approach to this pathology mainly depends on the size of the tumor, the anatomical localization and health status of the patient. The main surgical procedures performed are as listed: nodulectomy, regional mastectomy, monolateral mastectomy, and bilateral mastectomy which is usually not performed (Fossum C.S. 1997).

A brief summary of the surgical procedure is as follows: make an elliptical incision around the involved mammary gland(s), a minimum of 1 cm from the tumor; continue the incision through subcutaneous tissue to the fascia of the external abdominal wall; avoid incising mammary tissue (even if this is often impossible because mammary tissue may be confluent between adjacent glands); remember that the midline separation between mammary chains is distinct; control superficial hemorrhage with electrocoagulation, hemostats, or ligation; perform an en bloc excision by elevating one edge of the incision and dissecting subcutaneous tissue from the pectoral and rectus fascia using a smooth gliding motion of the scissors; use traction on the elevated skin segment to facilitate dissection; resect the inguinal fat pad and lymph nodes with the inguinal mammary gland (the axillary lymph node is not included with en bloc resection of the thoracic glands) excise fascia if the tumor has invaded subcutaneous tissue; remember that some neoplastic lesions may invade the abdominal musculature, and therefore the excision must include a portion of the abdominal wall; continue gliding the scissors and dissect until major vessels are isolated and ligate them; lavage the wound and evaluate for abnormal tissue; undermine the wound edges, and advance skin toward the center of the defect with walking sutures; appose skin edges with a subcutaneous or subcuticular suture pattern (skin apposition is most difficult in the thoracic region because the skin is less mobile, and the ribs make the area less compressible than the abdomen) (Fossum C.S. 1997); when the inguinal mammary gland needs to be removed, it is also suggested that even the regional lymph node must be removed, because it usually drains the gland. The removal of the axillary lymph node is suggested when the first, second and third mammary gland is affected, although it is difficult to approach due to the presence of the brachial plexus (Meuten D.J. 2002).

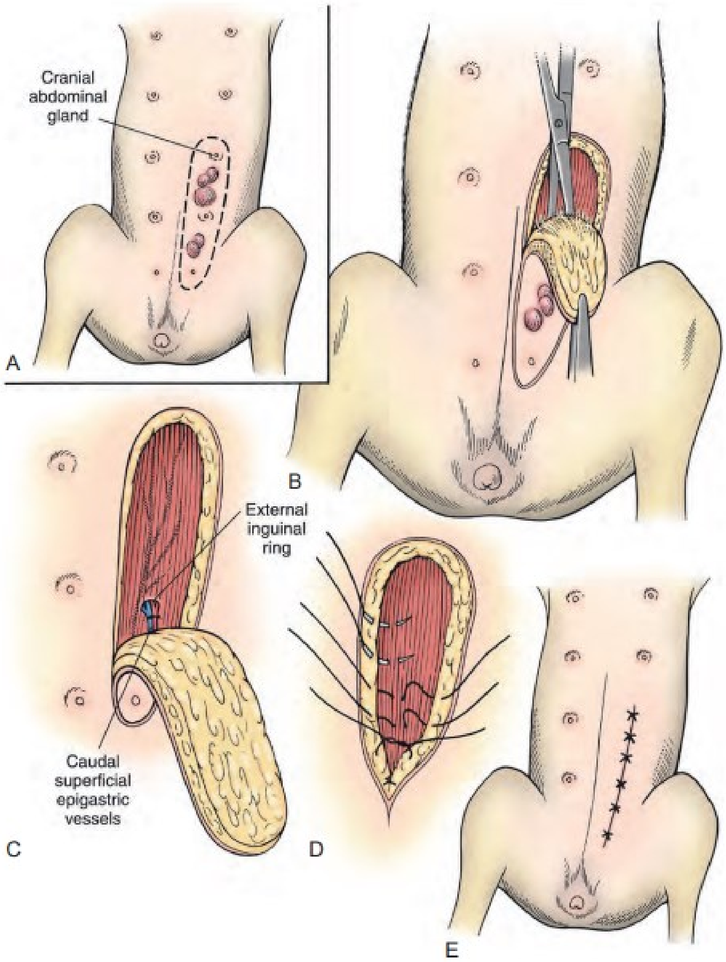


Figure 4.1 mastectomy procedure (Fossum C.S. 1997).

CHAPTER V: CLINICAL STUDY:

Aim of study:

This study aims to evaluate the pain management in dogs affected by mammary tumors that underwent a total monolateral mastectomy procedure with a combination of ultrasound guided blocks of serratus superficial plane block and transversus plane block (both paracostal approach and umbelical).

More specifically, it aims to evaluate if this combination of techniques is effective in managing the pain, both surgical and post theatre until six hours after recovery.

Methods and materials:

The present study was approved by the Ethical Committee of the University of Parma (PROT. N. 14/CESA /2023).

In this study 17 female dogs were included. The patients were referred to OVUD "Ospedale Veterinario Universitario Didattico" of the University of Parma and to "Clinica veterinary Apuane" of Carrara.

All dogs had a diagnosis of mammary tumors and were referred to the structure to undergo a total monolateral mastectomy procedure whereas when only a few mammary glands were removed, the dog was excluded from the study. Dogs that underwent in the same operation setting an ovariosterectomy were included too.

Aggressive or overstimulated dogs were also excluded due to the light premedication and the difficulty of monitoring with a Glasgow scale the post-operative pain. Dogs that were included were from different breeds: 2 Border Collie, 1 Boxer, 1 Italian Hound, 2 Golden Retriever, 2 Labrador, 4 mongrel, 2 Pinscher, 1 Poodle and 1 Pomeranian, and weight ranging between 5 and 40 kg, aged between 4 and 15 years.

Before the procedure all dogs underwent a preanesthetic evaluation, got their blood drawn for to monitor the biochemical and hematological parameters and a ECG a few days before the procedure.

Furthermore, patients had a Rx screening to check for possible metastasis with 3 projection of the thorax and a complete abdomen ultrasound was made based on their general health status. Afterwards they were classified with an ASA classification (American Society of Anesthesiologists) as an ASA 2.

Before the procedure the owners were informed on the type of procedure with its risks and the description of the regional anesthesia. The owner signed a written informed consent.

In this study, the following two blocks were chosen: TAP block with umbilical and paracostal approach controlling the abdomen analgesia, and then the serratus superficial block for controlling the trunk's analgesia.

All dogs underwent the same anesthesiologic protocol. A venous catheter was placed in one of the two cephalic veins to guarantee the correct administration of all drugs and fluids after having trichotomized and disinfected the area.

All dogs were premedicated with 0.2 mg/kg of methadone (Semfortan®, Dechra, Italia) IV.

Before induction all patients were pre-oxigenated with a flow by system (with masks if the patient was collaborative) with pure oxygen for at least five minutes.

The induction was performed with propofol (Proposure®, Merial, Italia) until the endotracheal intubation was possible; the dose of propofol ranged between 3 and 5 mg/kg IV. The patient was then intubated with a Murphy endotracheal tube of the appropriate size. Once intubated they were maintained with isoflurane (Isoflo®, Zoetis, Italy) delivered in a mixture between air and oxygen with a FiO_2 between 60-70% afterwards they started a fluid-therapy of Ringer Lactate (RL, SALF, Italia) at a velocity of 3-5ml/kg/h.

In all patients an arterial catheter was aseptically introduced in the metatarsal arteria to record invasive blood pressure values.

Then the patient was placed on lateral recumbency with the mammary line facing up, so that the thoracic wall and the abdominal wall could be trichotomized for the procedure and for the blocks. Afterwards the whole area was aseptically prepared for the blocks. Ultrasound guided blocks were performed using an ultrasound machine Midray Vetus E7 with a linear probe L13-3Ns.

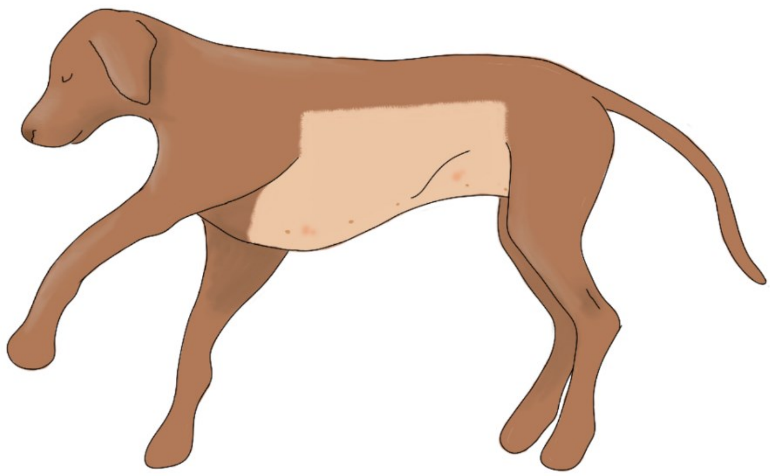


Figure 5.1: the placement of the patient in lateral recumbency.

The first type of block was the serratus superficial plane block described by Freitag (Freitag A.V. 2019); the execution of this block is possible only via ultrasound since is an intrafascial block. The probe is positioned on the thoracic wall (figure 5.2) perpendicular to the ribs so that the fourth and fifth rib could be seen, and it was placed at one third of the rib (starting dorsally) at the same height of the shoulder articulation.

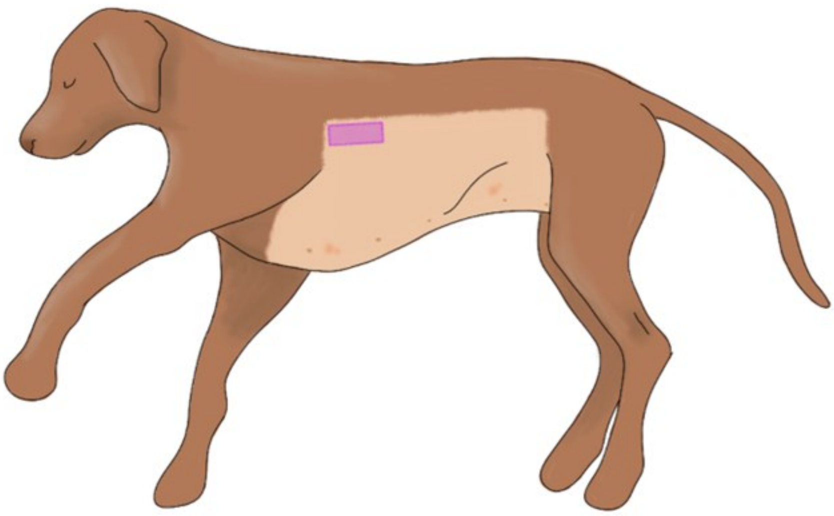


Figure 5.2: the probe positioning on the patient for the serratus plane block.

Via ultrasound (figure 5.3) the following muscles could be identified: the cutaneous dorsal muscle, longissimus dorsalis, serratus ventralis, the intercostal muscles and the pleura, ribs can even be identified since they rejected the sound meaning they were viewed as hypoechoic.

When the image was clear, a spinal needle 22Gx3”1/2 (Pic solution Artsana S.P.A., Italy 22Gx3”1/2) was inserted in plane sliding caudo-cranially until the tip reached the fascia between the latissimus dorsalis and the ventral serrate muscle. Once the target was attained, it was possible to inject the local anesthetic (before the operator checked for the syringe’s negative pressure to ensure a non-intravenous administration). Finally, the separation of the two-muscle fascia could be seen if the location was correct.

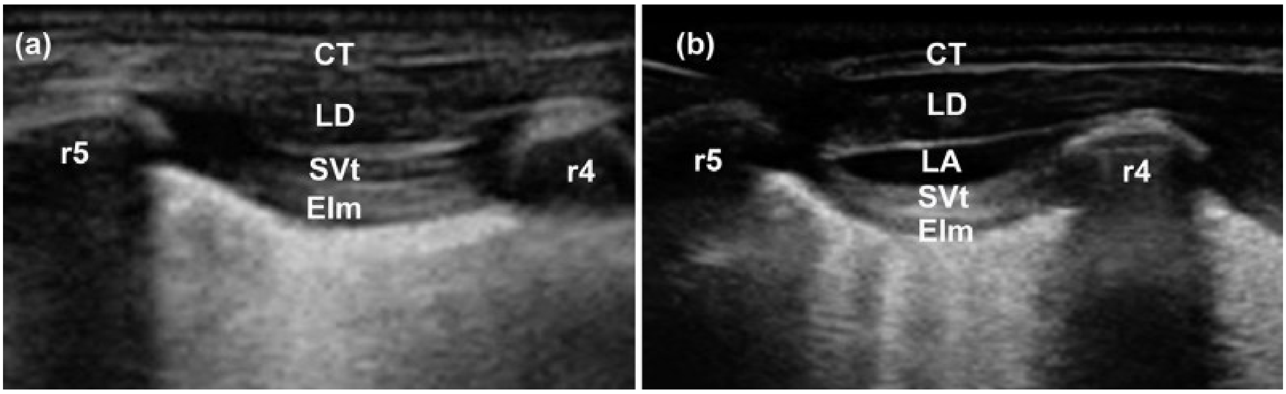


Figure 5.3: ultrasound image of the serratus plane block before and after the injection of the anesthetic (Freitag A.V. 2019).

For the serratus plane block the volume used was 0.3 ml/kg of Ropivacaine (Ropivacaina Kabi®, Fresenius Kabi, Italia) at a concentration of 0.35% diluted with saline solution (NaCl 0.9%).

Then, the two types of TAP block were performed: even the TAP block is an interfascial block, the targeted muscles are the muscle internal oblique of the abdomen and the transverse muscle of the abdomen, where the ventral branches of the last four intercostal and the first three of the lumbar nerves (from T9-L3) nerves can be found.

For the abdomen it was decided to do two blocks, one more cranial in the abdomen and one more caudal.

For the paracostal approach the probe was positioned caudally and parallel to the last rib at the corresponding height of L2-L3 (figure 5.4).

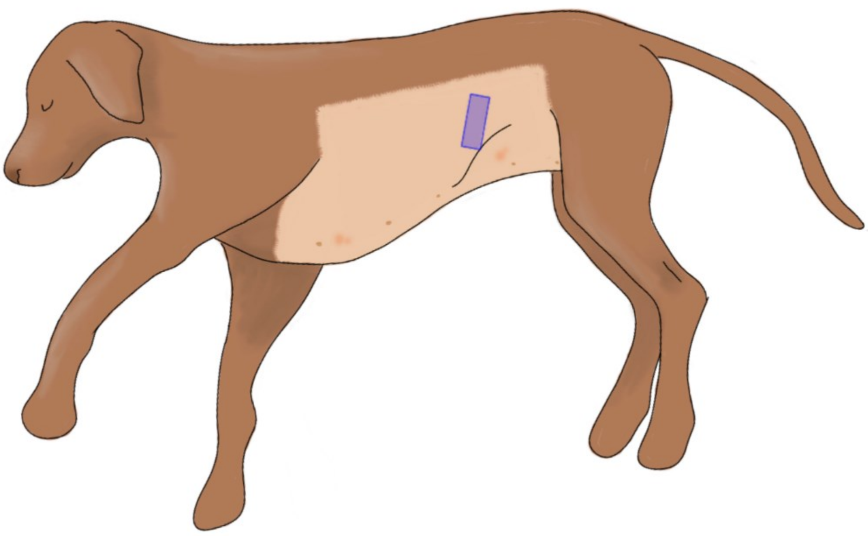
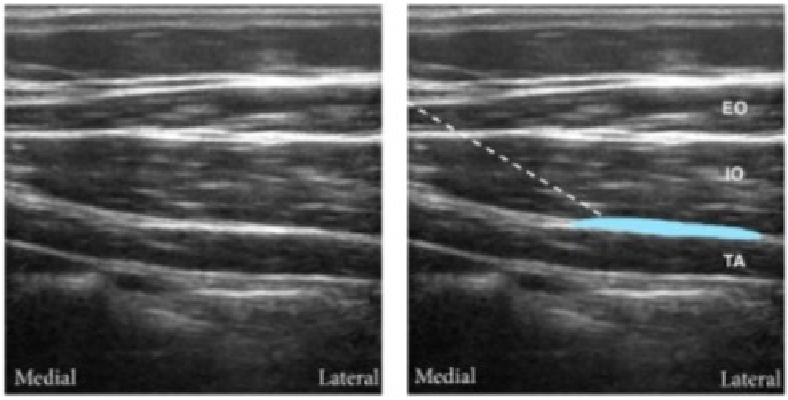


Figure 5.4: the positioning of the probe for the TAP block paracostal approach

In the ultrasound the imaging (figure 5.5) of the muscles that could be seen dorsoventrally were the external oblique muscle, internal and then the transversus abdominis muscle and the peritoneum. Once the target could be seen, a spinal needle (22Gx3"1/2) was inserted in dorso-ventral direction.



EO: External oblique muscle

IO: Internal oblique muscle

TA: transversus abdominis muscle

Figure 5.5: Ultrasound image of the TAP block and the site injection (Tsai HC 2017)

When the needle tip reached the desired site and it was located between the internal oblique muscle and the transverse muscle, local anesthetic was injected (before injection, the operator checked for the syringe's negative pressure to ensure a non-intravenous administration). As previously described, the separation of the two-muscle fascia could be seen if the location was correct.

In the second type of TAP block, the probe was positioned cranially to the iliac crest at the height of the intervertebral space of L5 to L6 (figure 5.6). Even in this case it was used the technique in plane and the needle proceeded dorso-ventrally.

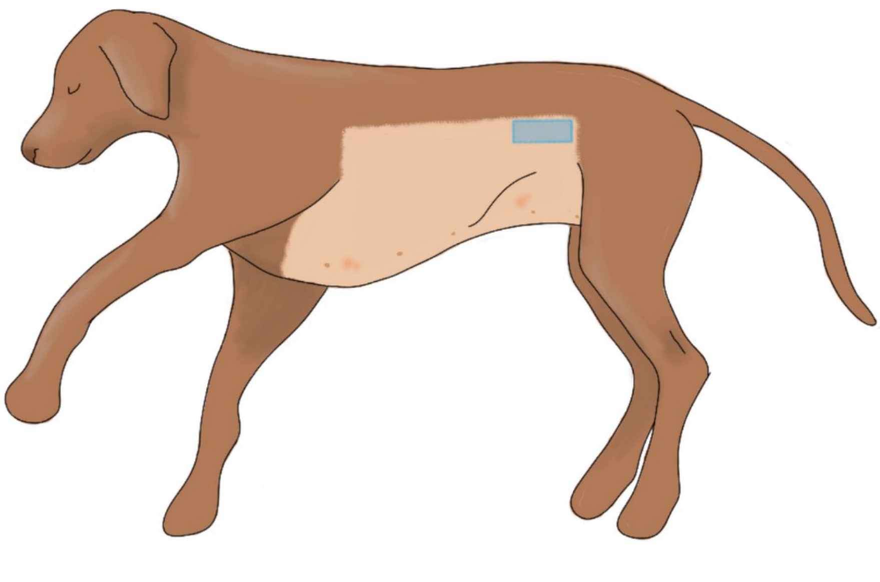


Figure 5.6: the positioning of the probe for the TAP block umbilical approach

For the TAP block the volume used was 0.15 ml/kg of Ropivacaine at a concentration of 0.35% diluted with saline solution (NaCl 0.9%).

During the surgical procedure, to evaluate the anesthetic plane, palpebral reflex and bulboocular positioning were evaluated; the following parameters were recorded using a multiparameter monitor (Datex S5, Ohmeda, Germany) every five minutes:

- heart rate;
- ECG;
- partial saturation of oxygen levels spO_2;
- invasive systolic arterial pressure (SAP);
- invasive mean arterial pressure (MAP);
- invasive diastolic arterial pressure (DAP);
- CO_2 concentration of final expiration ($ETCO_2$)
- Concentration of isofluorane expirated;

Other than the usual monitoring every 5 minutes, also the following surgical stages were recorded with the intraoperative monitoring:

- T0: 5 minutes before placement of the surgical drape;
- T1: placement of the surgical drape;
- T2: skin incision;
- T3: separation of tissue of the thoracic wall;
- T4: separation of tissue of the abdominal wall;
- T5: removal of the lymph nodes;
- T6: suture of the thoracic deep planes;
- T7: suture of the abdomen deep planes;
- T8: suture of the thorax's skin;
- T9: suture of the abdomen's skin;

The patients were mechanically ventilated and the ETCO2 was kept between ranges of 35 and 45 mmHg. Based on necessity during the anesthesia security protocols were performed in case of hypotension, the first line of action was a bolus of crystalloids at 5ml/kg and afterwards a Constant Rate infusion of Dobutamine or Norepinephrine.

In case of nociception, one bolus of 1 μg/kg of Fentanyl (Fentadon®, Dechra, Italy) was administered. Parameters that were considered a signal of nociception were as follows: an increase of heart rate or arterial blood pressure of 20% compared with the previous monitoring.

Furthermore, if the first bolus was not enough a second one could be administered. Then a continuous intravenous administration was made at 2 μg/kg/h, increasing or decreasing based on nociception.

Once surgery ended, the patient was awakened, extubated and then 0.2 mg/kg of meloxicam (Meloxydril, Ceva®, Italia) was administered SC.

All patients underwent a multiparametric evaluation of pain via Glasgow Composite Pain Scale (GCPS-SF: Glasgow Composite Pain Scale) (figure 5.7) (Della Rocca G. 2018) (Testa B. 2021) after the surgery's end right after the patient is fully awake and able to walk and at 1, 2, 3 4 and 5 hours after surgery. If the total score was over 5, a rescue analgesia was administered with 0.2 mg/kg of methadone IM. This multiparametric scale was performed by the same operator.

SHORT FORM OF THE GLASGOW COMPOSITE PAIN SCALE

Dog's name ______________________________

Hospital Number __________ **Date** / / **Time**

Surgery Yes/No (delete as appropriate)

Procedure or Condition ____

____

In the sections below please circle the appropriate score in each list and sum these to give the total score.

A. Look at dog in Kennel

Is the dog?

(i)		(ii)	
Quiet	0	Ignoring any wound or painful area	0
Crying or whimpering	1	Looking at wound or painful area	1
Groaning	2	Licking wound or painful area	2
Screaming	3	Rubbing wound or painful area	3
		Chewing wound or painful area	4

In the case of spinal, pelvic or multiple limb fractures, or where assistance is required to aid locomotion do not carry out section B and proceed to C
Please tick if this is the case ☐ **then proceed to C.**

B. Put lead on dog and lead out of the kennel.

When the dog rises/walks is it?

(iii)	
Normal	0
Lame	1
Slow or reluctant	2
Stiff	3
It refuses to move	4

C. If it has a wound or painful area including abdomen, apply gentle pressure 2 inches round the site.

Does it?

(iv)	
Do nothing	0
Look round	1
Flinch	2
Growl or guard area	3
Snap	4
Cry	5

D. Overall

Is the dog? (v)		*Is the dog?* (vi)	
Happy and content or happy and bouncy	0	Comfortable	0
Quiet	1	Unsettled	1
Indifferent or non-responsive to surroundings	2	Restless	2
Nervous or anxious or fearful	3	Hunched or tense	3
Depressed or non-responsive to stimulation	4	Rigid	4

Total Score (i+ii+iii+iv+v+vi) = ______

Figure 5.7: Glasgow pain scale in dogs from the University of Glasgow

Statistical analysis:

Data were analyzed for normal distribution with a test of analysis of two-way analysis of variance by ranks by Friedman with correlated samples; statistical significance was set at $p < 0.05$.

Results:

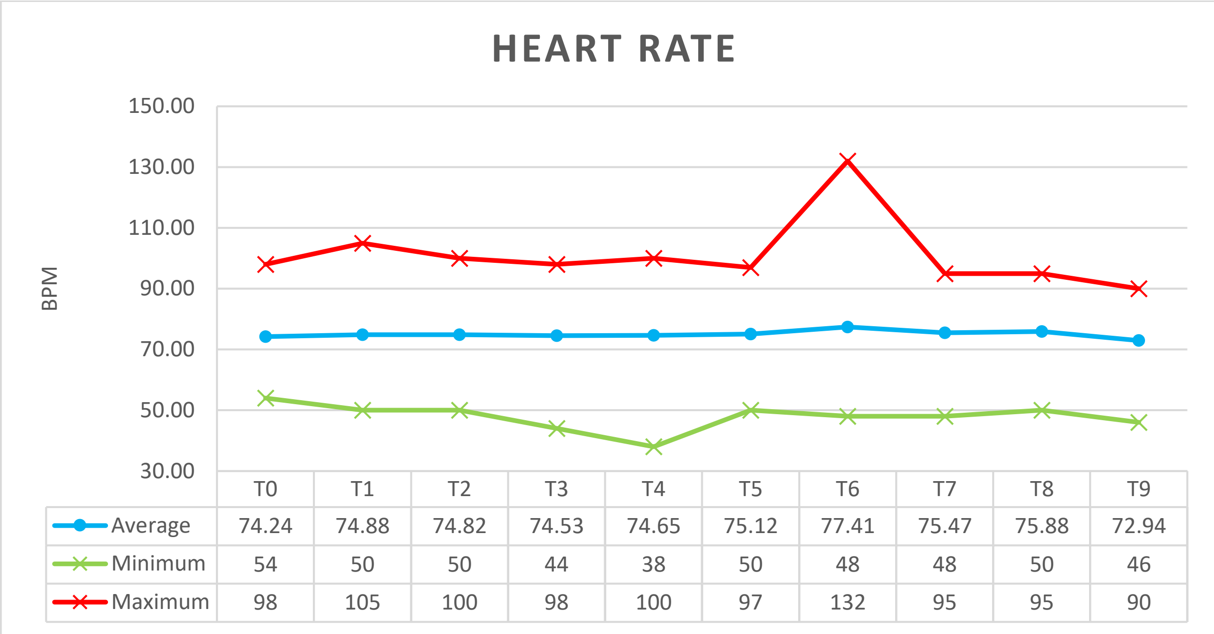
In this study were included 17 female dogs of different breeds as listed in table 5.8. Their ages were ranging between 4 and 15 years old on average 9.29 years old and weighing from 5 to 40 kg on average 20.76 kg. Based on the clinical exams and bloodwork all patients were classified as ASA 1 or 2.

Breed	Age	Weight	kg
Border collie	10	20	kg
Border Collie	11	25	kg
Boxer	9	30	kg
Italian Hound	8	37	kg
Golden Retriever	9	30	kg
Golden Retriever	4	40	kg
Labrador	7	40	kg
Mongrel	8	17	kg
Mongrel	7	8	kg
Mongrel	9	18	kg
Pincher	8	8	kg
Pincher	12	8	kg
Pomeranian	15	5	kg
Mongrel	9	16	kg
Labrador	9	25	kg
Poodle	12	6	kg
Mongrel	11	20	kg
Average	**9.29**	**20.76**	**kg**
Total		**17**	**cases**

Table 5.8: all cases that were included

The time between performing all blocks and the beginning of surgery ranged from 10 to 45 (on average of 30) minutes.

In the following graphics are reported the average values, minimum and maximum of heart rate, arterial blood pressure (Systolic, Mean and Dyastolic), $ETCO_2$ and the exhaled fraction of Isofluorane in the following Anticholinergic, inotropic, or vasoactive drugs were not required to support cardiovascular function in any case.



	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Average	74.24	74.88	74.82	74.53	74.65	75.12	77.41	75.47	75.88	72.94
Minimum	54	50	50	44	38	50	48	48	50	46
Maximum	98	105	100	98	100	97	132	95	95	90

Table 5.9: graphic of the minimum, maximum and average of the heart rate

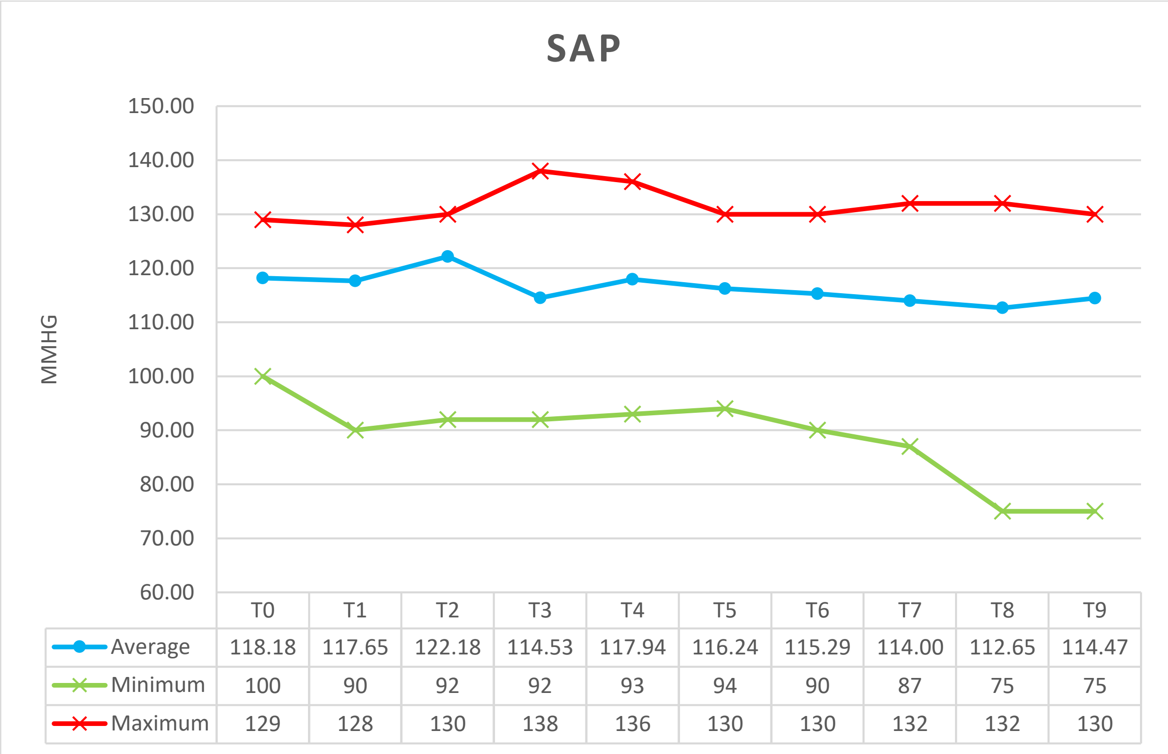
No alterations in the cardiac rhythm were registered.

The heart rate was registered between 44 and 132 bpm.

The average ranges between 74.23 and 77.41 bpm there are non-significant differences between time points.

Whereas the minimum has a progressive decrease, which is not statistically significant, starting from T2 (incision of the cutis) and decreases until T4 the decreasing is of 24%.

The maximum has a peak, not statistically significant, at T6 (stitching of the deeper tissues) with an increasing of 34.69%.



	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Average	118.18	117.65	122.18	114.53	117.94	116.24	115.29	114.00	112.65	114.47
Minimum	100	90	92	92	93	94	90	87	75	75
Maximum	129	128	130	138	136	130	130	132	132	130

Table 5.10: graphic of the minimum, maximum and average of the Systolic arterial blood pressure

The Systolic arterial blood pressure ranged between 138 and 90 mmHg. The average maximum was at the incision of the trunk (T2).

The average was between 112.64 and 118.18 mmHg and stays constant. The trending of minimum and maximum has no significant difference.

The minimum progressively decreases from 100 mmHg to 75 mmHg resulting in a 25% decrease.

The maximum stays constant and all variations remain under 20%. These changes were not statistically significant.

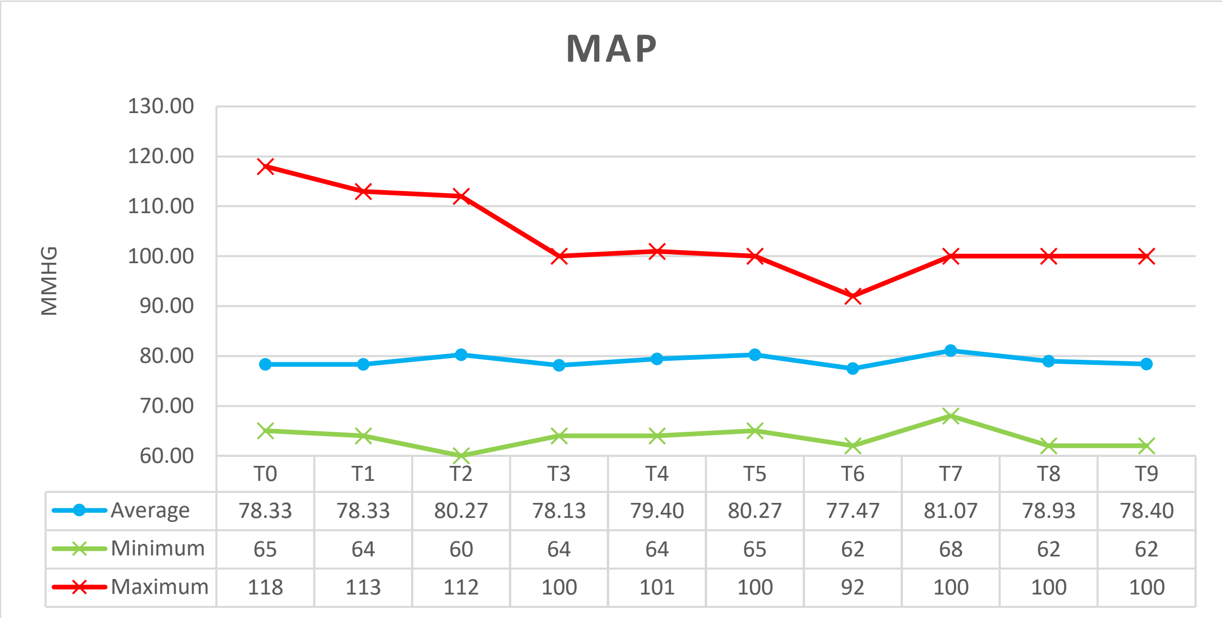
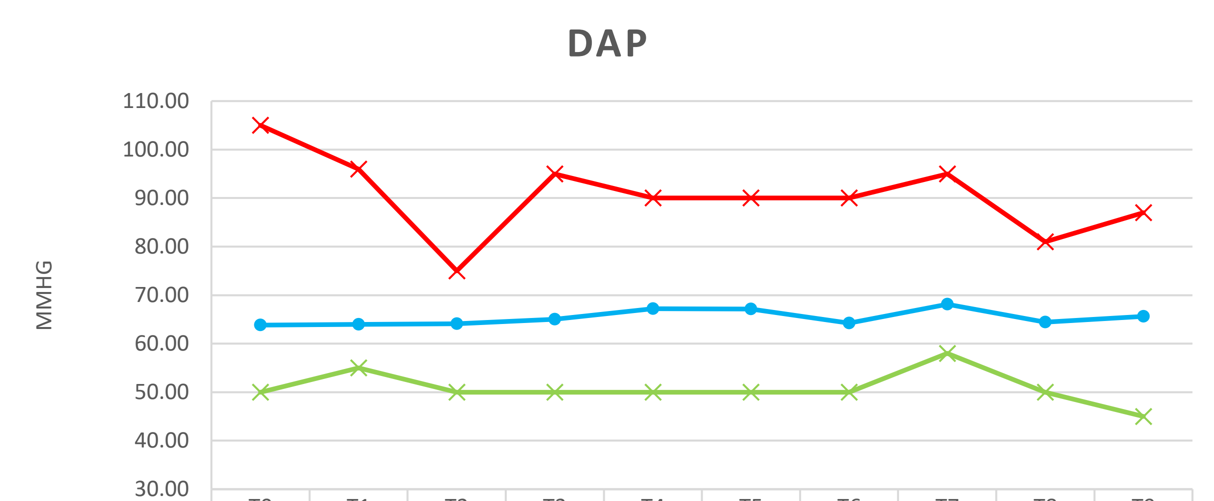


Table 5.11: graphic of the mean arterial blood pressure

Mean arterial blood pressure remained between 60 and 118 mmHg in all dogs. It does not vary much. The average values ranged from 77.47 to 81.07 mmHg. The trending of minimum and maximum has no significant difference.

The maximum decreases starting from T0 until T3 meaning it starts from 5 minutes before the apposition of the drapes until the incision of the abdomen, decreasing of 22%. These changes were not statistically significant.



	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Average	63.82	63.94	64.12	65.06	67.18	67.12	64.24	68.12	64.41	65.65
Minimum	50	55	50	50	50	50	50	58	50	45
Maximum	105	96	75	95	90	90	90	95	81	87

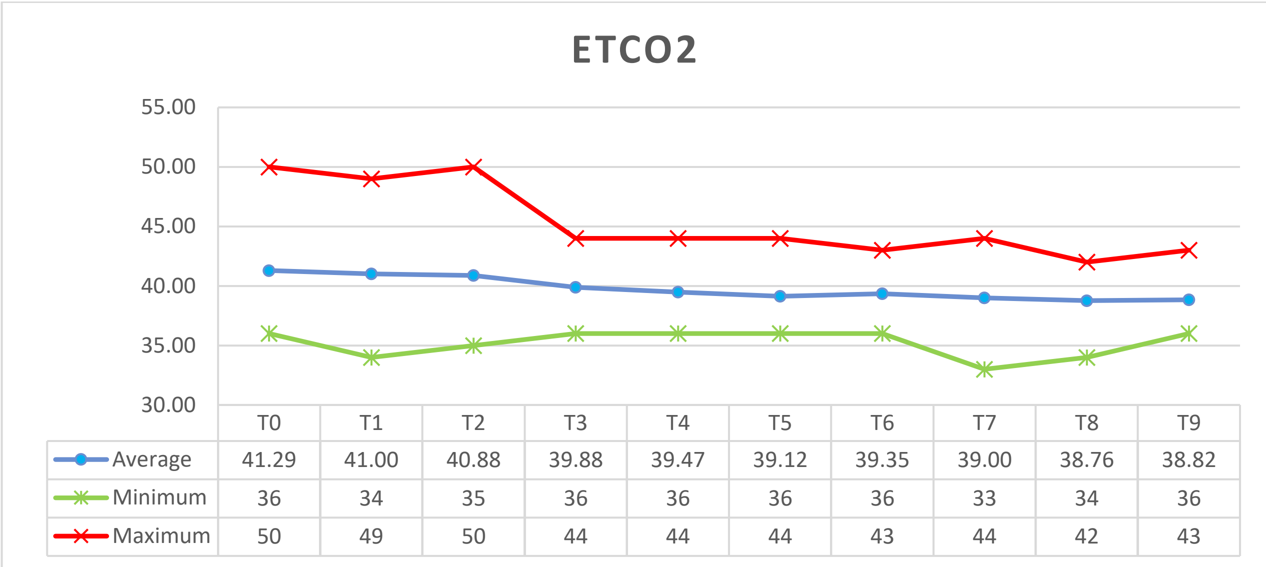
Table 5.12: graphic of the minimum, maximum and average of Diastolic arterial blood pressure

The diastolic arterial pressure ranged between 50 and 105 mmHg, the average value is between 63 and 67 where the maximum is reached during the stitching of the deeper tissues of the abdomen (T7).

The average stays between 63.75 and 67.68 mmHg. The trending of minimum and maximum have no significant difference.

The minimum stays constant as well and all variations remain under 20%; these changes were not statistically significant.

The maximum has a decrease of 30% with its peak at T3 where the incision of the trunk starts; these changes were statistically significant compared to T2.

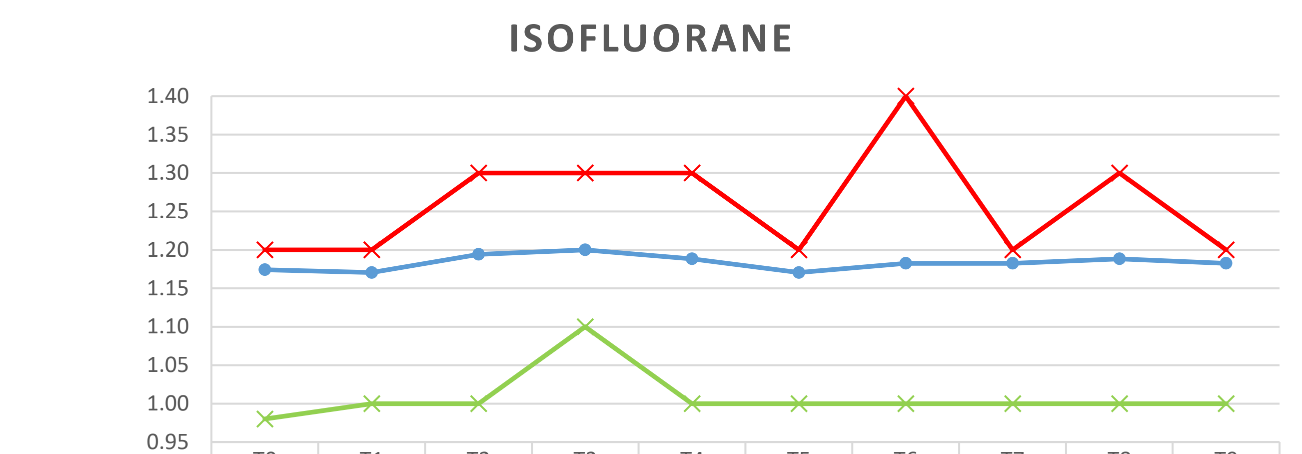


	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Average	41.29	41.00	40.88	39.88	39.47	39.12	39.35	39.00	38.76	38.82
Minimum	36	34	35	36	36	36	36	33	34	36
Maximum	50	49	50	44	44	44	43	44	42	43

Table 5.13: graphic of the minimum, maximum and average of $ETCO_2$

$EtCO_2$ was kept between 35 and 50 mmHg during anesthesia. There were no significant changes. The average stays constant and ranges between 38.76 and 41 mmHg. The trending of minimum and maximum has no significant differences.

Both maximum and minimum stay constant and have no variations over 20%; these changes are not statistically significant.



	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Average	1.17	1.17	1.19	1.20	1.19	1.17	1.18	1.18	1.19	1.18
Minimum	0.98	1	1	1.1	1	1	1	1	1	1
Maximum	1.2	1.2	1.3	1.3	1.3	1.2	1.4	1.2	1.3	1.2

Table 5.14: graphic of minimum, maximum and average exhaled isofluorane

In all dogs, FE ISO was maintained below 1.4 % (median: 1.17, range:0.98–1.4). There were no significant changes.

On average the expirated isofluorane stayed between 1.17 and 1.2 %. The trending of minimum and maximum has no significant differences.

The minimum and maximum stayed constant and have no variations over 20%.

Subjects	Bolus	Stages
Case 1	1	T3
Case 2	1	T4
Case 3	0	
Case 4	1	T4
Case 5	0	
Case 6	0	
Case 7	1	T3
Case 8	0	
Case 9	0	
Case 10	0	
Case 11	0	
Case 12	1	T5
Case 13	3	T3, T7, T8
Case 14	3	T2, T6, T8
Case 15	2	T5, T7
Case 16	1	T7
Case 17	1	T5
Average	**1.5**	

Table 5.15: bolus of fentanyl per case

Surgical stages	T1	T2	T3	T4	T5	T6	T7	T8	T9
Total bolus of Fentanyl	0	0	3	2	3	1	3	2	0

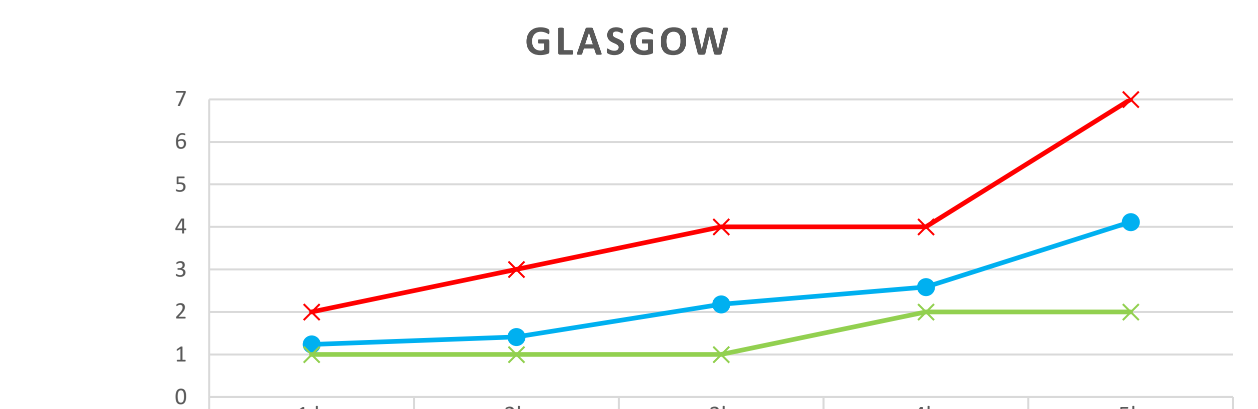
Table 5.16: total bolus of fentanyl per surgical stages

During the operation, an intravenous bolus of Fentanyl (1 mcg/kg) was administered as rescue analgesia in 10 dogs out of 17. Rescue analgesia Analgesia had an average dose of 1.5 mcg/kg, as shown in (Table 5.15).

As it can be seen in (Table 5.16), the surgical stages that needed a rescue analgesia are: T3, T4, T5, T6, T7 and T8.

Surgery time ranged from 45 to 100 minutes (median 60) minutes.

Recovery from anesthesia was smooth and no complications were recorded.



	1 h	2h	3h	4h	5h
avarage	1.235294118	1.411764706	2.176470588	2.588235294	4.117647059
minimum	1	1	1	2	2
mazimum	2	3	4	4	7

Table 5.17: Results of the Glasgow's scale

Postoperative pain was evaluated using a Glasgow scale. Pain scores are reported in table 5.17.
None of the dogs showed signs of discomfort after applying gentle pressure on the wound zone and pain scores remained below 5 during the first five hours post-surgery. Not all patients were assigned a 5 or higher evaluation at the fifth hour; 12 out of 17 needed a sixth hour of evaluation where they all scored over 5.
After the first hour the score remained under 2 and at the second it remained under 3, at the fourth and fifth hour it stayed under four and at the fifth it ranged between 2 and 7.
After that period, all dogs received methadone (0.2 mg/kg intramuscularly every 4–6 hours) for post-operative analgesia. All patients were dismissed to the intensive care unit and discharged around 24 hours after surgery.
No complications related to the anesthetic or surgical procedures were noted in the two-week follow-up period in any patient.

Discussion:

This study evaluated the clinical efficacy of the combination of the transversus abdominis plane block and the serratus plane block in dogs undergoing a radical monolateral mastectomy.

This anesthetic procedure aimed to guarantee a block of nociception from the thorax wall and abdomen during the surgical procedure and the following hours to reduce the administration of opioids and post-surgical stress.

The canine abdomen wall and mammary glands are innervated by the ventral branches of nerves from T11 to L3, whereas the thoracic mammary glands are innervated by the most cranial branches of the lateral cutaneous nerve branches from T3 to T6, and the most caudal branches of lateral cutaneous branches of T6 and T7 nerves (Lahuta A. 2013).

Due to this innervation, it was already supposed by Teixeira and colleagues that the combination of the Transversus abdominis plane block (TAP block) and the serratus plane block (SP block) can interfere with nociception for all mammary lines during the operation (Teixeira L.G. 2018). The results obtained by these authors showed great analgesia during surgery and the following two hours afterward. Then, two types of blocks were performed. the serratus block was performed in two sites: the first one at the fourth intercostal space and the second at the ninth, the local anesthetic was injected between the serratus ventralis muscle and the external intercostal muscle. Afterward, there were performed twoapproaches of TAP blocks: for the first TAP block the probe was positioned caudally to the last rib, and for the second TAP, it was placed cranially to the iliac crest. The authors chose Bupivacaine as a local anesthetic diluted at 0.25% with saline solution NaCl at 0.9% and the volume chosen was 0.3 ml/kg (Teixeira L.G. 2018).

In our study, we decided to follow Freitag's approach with the superficial serratus block in only one site of injection (Freitag A.V. 2019). and not Teixeira's approach. Freitag and colleagues injected the local anesthetic between the latissimus dorsal muscle and the serratus ventralis because the cutaneous branches of the thoracic nerves are at that depth, as hypothesized by Bailey (Bailey C.S. 1984). For him, the branches that innervate the thoracic wall are the cutaneous lateral branches of T2 to T11 and they are responsible for the nociception perception of stimuli.

The choice of a superficial block rather than a deep was due to Blanco's study where it is reported a larger spread and a longer effect in the superficial approach in human beings (Blanco R. 2013). In Freitag and Gaio's study, the needle is introduced between the fourth and fifth rib at the shoulder's height with a volume between 0.3 and 1 ml/kg. The local anesthetic spread covers from T1 to T9, and this provokes analgesia in the most cranial and mean portion of the thorax. The authors did not find any significant difference between the different volumes and spread, so they suggest using a lower volume to prevent any form of local anesthetic toxicity. That it is why we chose the lower volume of 0.3 ml/kg for the serratus plane block.

For the TAP block, it was decided to follow Teixeira's study for a mastectomy with a double site injection (Portela D.A. 2014) (Teixeira L.G. 2018).

Methadone was administered as pre-anesthetic medication at 0.2 mg/kg IV because this kind of premedication caused a mild sedation. Furthermore, it could have also produced antinociception and therefore participated in reducing intraoperative fentanyl consumption. Considering methadone pharmacokinetics in dogs (Ingvast-Larsson C 2010), it helps to manage post-operative pain, and it is unlikely that at the dose used, methadone could produce a degree of such antinociception and post-operative analgesia to interfere with the study's result. However, a prospective study including a control group could be useful to better assess the antinociceptive efficacy of the serratus and TAP block in dogs. However, the choice of administering an opioid is also due to ethical reasons.

Statistical analysis has not shown any significant changes in HR, SAP, MAP expired isoflurane and $ETCO_2$. Whereas only DAP had a significant increase at T3 during the separation of deeper tissues of the thoracic wall. It likely that this could be explained by an algic stimulus that is not covered by the serratus plane block at that depth.

Surgical stages that required rescue analgesia are as follows:

- cases 1, 7, and 13 at the separation of the deeper tissues of the thorax (T3)
- cases 13, 15, and 16 during the stitching of the deep tissues of the abdomen (T7)
- cases 12, 15, and 17 during the ligation of the inguinal canal vessels (T5)
- cases 13 and 14 during the stitching of the cutis of the trunk (T8)
- case 2 and 4 during the separation of the deeper tissues of the abdomen (T4)
- case 14 at the stitching of the deep tissues of the trunk (T6)

The patients that needed rescue analgesia during the dissection of the thoracic tissues were seven, more specifically three patients needed a bolus of Fentanyl during the separation of the deeper tissues of the thorax, two during the stitching of deep tissues, and only one patient during the stitching of the most superficial tissues of the thorax. It is possible that in these patients, the local anesthetic did not reach the cutaneous lateral branches more caudal of T9 as described in Freitag's study (Freitag A.V. 2019). Further studies are needed to determine if a higher volume can reach better these branches.

Only two cases needed rescue analgesia during the traction of the deeper tissue of the abdomen. Comparing this result to other studies, it can be possible that the local anesthetic did not reach the ventral branches of T11 as explained by Johnson and afterward even Romano and colleagues (Romano M. 2020) (Johnson E.K. 2018).

Nevertheless, it is mandatory to keep in mind that this comparison was made with a study that used cadavers that were frozen meaning that the local anesthetic can spread differently due to the process of freezing that can alter the anatomical structures (Freitag A.V. 2021).

Last but not least, the three subjects that had nociceptive stimuli during the ligation of vases of the inguinal canal confirm the hypothesis of Portela and colleagues that the TAP block cannot cover the nociceptive stimuli due to its innervation by the genitofemoral nerve which is not covered by this type of block (D. A. Portela 2014).

Nevertheless, as stated by Vettorato and colleagues, a nerve block can be considered effective if the rescue analgesia of Fentanyl is lower or equal to 2.1 mcg/kg/h (E. Vettorato 2012). In our study, the average between the cases that needed fentanyl is 1.5 mcg/kg meaning that this combination of blocks was effective for this procedure.

For the post-operative monitoring the data shows that during Glasgow’s multiparametric scale the score remained under 3 during the first two hours and remained under 5 in the first five hours meaning that this combination of blocks determines a good analgesia for both the thoracic and abdominal wall, so it reduced the post-surgery stress. the value of the scale increases due to the local anesthetic slowly wearing off.

Conclusion:

In conclusion, from this study, it was confirmed that the combination of the serratus plane block and the transversus abdominis plane block can prevent the nociceptive stimulus of the thoracic wall and of the abdomen in dogs undergoing a radical monolateral mastectomy, and it can reduce the administration of opioids during both intra and post-operative period.

As shown by the results, this combination of regional anesthesia can reduce the consumption of systemic analgesic molecules, so they can be considered and added to the protocol of multimodal approach, especially to manage pain during this kind of procedure.

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