A new emerging concept in human medicine is starting to spark interest within our veterinary specialty hospitals. Enhanced Recovery After Surgery (ERAS), also known as a fast-track or enhanced-recovery pathway, is a new approach that involves rethinking the preoperative, intraoperative, and postoperative periods. The ultimate, overarching aim is to improve patient outcome following surgery and, thus, return to a normal daily routine as soon as possible. The development and implementation of locoregional anesthetic techniques in humans is one of the key elements driving these protocols. In veterinary medicine, we are no exception; the rapidly growing interest, development, and refinement of these techniques in our veterinary species is changing the way we think of anesthesia and analgesia. The potential real benefits are yet to be determined, as this concept is implemented into our veterinary hospitals in general, and our surgical patients in particular, in a more systematic and routine way. In this article, we will introduce the reader to the concept of ERAS protocols and the role of regional anesthesia in some common surgical procedures.
that “home readiness” is not equivalent to “street fit” when talking about discharge criteria.

Anesthesia and ERAS

In preparation for general anesthesia, fasting time should be optimized with the goal of minimizing stomach content volume and optimize gastric content pH, thus decreasing the incidence and severity of potential esophagitis from silent regurgitations or the severity and risk of aspiration pneumonitis. Savvas et al. suggested that, in the dog, a light meal 3 hours prior to premedication would decrease stomach content pH the least. In our institution, a 6-hour fasting time is still recommended. We prescribe antiemetics and medication such as proton pump inhibitors (e.g., omeprazole) to be administered prior to admission the day of the procedure. Allowing patients access to water until the time of premedication will ensure optimal patient hydration and avoid unnecessary delays or intraoperative hydration status corrections. Among the drugs commonly used in anesthesia, short-acting drugs with minimal residual effects are preferred (e.g., propofol and sevoflurane). Locoregional anesthesia in conjunction with a light plane of hypnosis is becoming the preferred method of providing general anesthesia in small animals, allowing for a significant decrease in opioid requirements or even opioid-free anesthesia. Undesirable opioid associated side effects in our small animal species may include sedation, ventilatory depression, emergence dysphoria, nausea and/or inappetence. The recovery process should include opioid-sparing drugs, such as nonsteroidal anti-inflammatory drugs, acetaminophen (paracetamol), and gabapentinoids (e.g., gabapentin and pregabalin), unless there are known contraindications to their administration. Antiemetics such as maropitant as well as proton pump inhibitors such as omeprazole or pantoprazole may also be prescribed to minimize the effects of fasting and thus encourage early return to eating. Opioids may be used sparingly as “rescue” medication on an as-needed basis rather than on a scheduled basis.

The role of locoregional anesthesia in ERAS protocols

Locoregional analgesia in the dog (peripheral nerve blocks and neuraxial anesthesia) is associated with early mobilization and return to normal behavior, potentially, leading to decreased hospital stays and early discharge. Opioid-sparing analgesic techniques may also be indicated in obese patients with high body condition scores. Opioid ventilatory depression can be aggravated and enhanced by obesity and may lead to potential severe respiratory depression and subsequent hypercapnia and hypoxia during the recovery period potentially delaying discharge. Advancements in ultrasound technology have represented a breakthrough in the field of regional anesthesia with development of new techniques and refinement of existing ones. Ultrasound-guided peripheral nerve blocks are unique since the target nerve or structure can be visualized and the needle trajectory can be tracked and controlled in real time, thus reducing the risk of trauma to sensitive surrounding anatomy, including the nerves, vessels, and other anatomic structures such as pleura. Traditional locoregional techniques such as epidural anesthesia are being revisited in small animals and substituted for more selective locoregional techniques in many surgical procedures. The incidence of associated observed side effects with neuraxial techniques such as intraoperative hypotension, postoperative residual motor paralysis, or urinary retention is significantly decreased in the dog, making peripheral nerve blocks preferred. More recently, ultrasound-guided fascial plane blocks (injection of local anesthetic within a selected fascial plane to target nerves that run through that plane) are gaining popularity, and a number of injection techniques are being described and successfully adapted from human anesthesia to be used in the dog.

Currently, there are no standards in veterinary anesthesia regarding ERAS protocols and locoregional anesthesia for individual surgical procedures; however, there is enough published literature and clinical information to make some informed recommendations. The use of long-acting local anesthetics such as bupivacaine or ropivacaine with the possible addition of coadjuvants such as dexmedetomidine is recommended since their prolonged analgesic effect will be carried over into the early postoperative period. However, this more conventional approach does not appear to provide more than 24 hours in the dog. Recently, the use of bupivacaine liposome suspensions is receiving some attention. This formulation is claimed to offer up to 72 hours in duration of action, which makes it especially interesting in this setting. So far, it has been successfully used in dogs undergoing tibial plateau leveling osteotomy (TPLO) as part of a nonspecific periarticular soft tissue infiltration. Their use has also been reported in the cat as part of soft tissue infiltrations. Additionally, its use has been described in the dog and as part of a peripheral nerve block as well as part of fascial plane blocks in other surgical procedures such as laparatomies among others.

Pelvic limb surgery

Saphenous nerve block—Its use has been described in surgical procedures such as TPLO, tibial tuberosity advancement, extracapsular lateral suture stabilization, and meniscectomies, among other orthopedic procedures involving the canine stifle (all in combination with a sciatic nerve block). The main benefit of this block is that it does not cause motor paralysis of the quadriceps group; therefore, it is preferred to epidural anesthesia and even a femoral nerve block since it allows for the patient to remain ambulatory. When combined with a sciatic nerve block, complete anesthesia of almost the entire stifle joint can be achieved. In this instance, sciatic deficits will be observed in the blocked limb and was first described by Costa-Farre et al in 2011. The technique (Figure 1) is well described previously.
Kalamatas et al reported successful use of this block in combination with a sciatic nerve block in dogs undergoing unilateral TPLO surgery. These authors reported no need for rescue analgesia in any of the dogs for the first 24 hours postoperatively. Ferrero et al reported an analgesia that was similar in quality to epidural anesthesia but with significantly less side effects such as intraoperative hypotension or postoperative urinary retention. These reported qualities may indicate initial suitability for implementation in ERAS protocols.

Of special interest is the publication by Boesch et al in which the authors reported the use of radiofrequency ablation for the treatment of uncontrolled pain associated with severe stifle osteoarthritis.

**Sciatic nerve block**—A sciatic nerve block, in conjunction with a saphenous nerve block, may be used in surgical procedures involving the stifle, tibia, foot, and ankle. It is important to note that this block will cause sciatic nerve deficits such as knuckling and a pseudohypermetric gait due to the inability to flex the ankle (hock). This deficit may last for up to 24 hours depending on the local anesthetic and the volume used. Communication with the surgeon and client is important to preempt confusion. A soft bandage or padding to protect the dorsal aspect of the foot and minimizing walking on abrasive surfaces should be strongly advised to avoid causing ulcerations of the dorsal aspect of the paw.

The ultrasound-guided caudal approach was first described by Campoy et al (Figure 2). More recently, 3 manuscripts have been published describing and evaluating its clinical use. Alternatively, an intraoperative infiltration of the posterior capsule or an ultrasound-guided preoperative infiltration in between the popliteal artery and joint capsule has been proposed in human anesthesia targeting the genicular nerves and sensory only terminal branches. A letter to the editor reporting successful implementation of this technique in the dog was published in 2020.

**Abdominal Surgery**

For major abdominal surgery, epidural anesthesia may still be the recommended and most often used technique. However, new fascial infiltration techniques such as the transverse abdominis plane (TAP) block can be of special interest. Perhaps still too premature to recommend one versus the other, but fascial plane blocks are becoming increasingly popular as part of a multimodal approach. The advantage versus epidural anesthesia is the absence of side effects such as postoperative motor impairment of the pelvic limbs from the local anesthetic or the possible urinary retention from the administration of opioids (morphine, perhaps the most prevalent).

One exception can be the use of neurexial (epidural) anesthesia in cesarean sections in which low-dose (“walking”) epidural anesthesia is still the preferred technique. For abdominal procedures, 2 techniques are of special interest and...
worth mentioning: the TAP block and the quadratus lumborum (QL) block.

**TAP block**—This fascial plane infiltration targets the relevant ventral spinal branches traveling in between the transverse abdominis and internal oblique muscles of an area in the dog that extends from dermatomes T9 to L3 (Figure 3). The abdominal wall and, possibly, the skin (depending on whether or not the local anesthetic extends as far as the lateral cutaneous branches), but not the internal abdominal organs will be desensitized. However, some studies in humans claim that this block also provides visceral as well as somatic analgesia. The lateral cutaneous nerves, at this level, branch off fairly proximal and leave the transverse abdominis plane going through the internal and external oblique muscles to supply the skin. The TAP block is perhaps the best described and studied fascial plane infiltration in the dog to date and slight variations in the execution of this technique have been published. This block may be of particular interest in procedures involving the abdomen and abdominal wall, such as splenectomies, liver surgery as well as mass removals, herniorrhaphies, or laceration repairs among others. Its clinical use in dogs undergoing ovariohysterectomy has been recently reported. In this study, the authors claimed lower postoperative pain scores, less need for rescue analgesia and lower overall opioid consumption compared with a parenteral opioid-based group.

Pain management with epidural anesthesia may be of better quality since it provides anesthesia not only to the abdominal wall but also to the internal abdominal organs. However, a TAP block is fast to execute, it does not require extra clipping, and it appears to provide adequate postoperative analgesia for abdominal procedures. In addition, this infiltration will not interfere postoperatively with ambulation or urinary control as it may be the case with epidural anesthesia, thus making it perhaps better suited for ERAS protocols. Further clinical studies comparing these 2 techniques are needed before we can make specific recommendations.

**QL block**—Initially described by Garbin et al in the dog and by Argus et al in the cat. It targets the ventral branches of the thoracolumbar spinal nerves (approx T13 and L3) as they travel between the QL and the psoas muscle (it can vary a little depending on the approach; Supplementary Figure S1). The infiltration site is proximal to where the lateral cutaneous branches leave the nerves and, in many cases, the local anesthetic spreads toward the sympathetic trunk approximately between T10 and L4. Therefore, it is claimed to provide not only somatic but also visceral analgesia to the abdomen. This relatively newly described fascial infiltration
does not spread beyond L3, and it does not appear
to cause any epidural migration, making it interest-
ing for ERAS protocols in procedures involving the
abdomen because it does not appear to cause motor
deficits of the pelvic limbs or any urinary retention. It
can be used in procedures such as ovariohysterecto-
mies or cholecystectomies. Additionally, it can be
used to produce analgesia in cases such as pancre-
atitis or gallstones.

**Thoracic wall surgery**

Major thoracic surgery may be beyond the scope
of ERAS protocols; however, there may be various
surgical procedures involving the thoracic wall that
may be considered. It is worth noting that thoracic
wall pain may lead to postoperative respiratory com-
plications and thus make these techniques good
complements or even alternatives to a pure opioid-
based analgesic protocol.

**Serratus plane block**—Developed to supple-
ment anesthesia for thoracic procedures such as
sternotomies (bilateral block), intercostal thora-
cotomies, thoracic wall defects or masses, skin
flaps, broken ribs, rib resections, etc. Proposed as a
simpler approach to thoracic paravertebral blocks or
even epidural anesthesia. Two different infiltrations
have been described: the deep infiltration was first
described by Drozdzynska et al. A few years later,
Freitag published the superficial infiltration. This
fascial plane infiltration targets the relevant ventral
spinal branches traveling in between the serratus
ventralis muscle and the external intercostal muscle
for the deep infiltration and the serratus ventralis and
latissimus dorsi muscle for the superficial infiltration
at the level of T4 or T5 (Supplementary Figure S2).
So far, both techniques appear to be effective at pro-
viding analgesia to the thoracic wall with no compli-
cations reported.

**Intercostal nerve block**—The use of intercos-
tal nerve blocks has been described for quite some
time. Reported to be an effective tool in the man-
agement of postoperative analgesia following in-
tercostal thoracotomies. Intercostal nerve blocks
have been reported to improve postoperative re-
spiratory parameters compared with parenteral
opioids in dogs undergoing thoracotomy. The
intercostal nerve travels on the surface of the pari-
etal pleura and therefore the precision of any blind
approach has a low success rate. Additionally,
the lateral cutaneous branch is often missed and
therefore the skin often times is not desensitized
with this technique. Recently, intercostal nerve
blocks are recently gaining new popularity in the
light of ultrasound-guided techniques (Figure 4).
Thomson et al reported a significantly increased
success rate, irrespectively of the level of expertise
in regional anesthesia, between a blind versus an
ultrasound-guided technique.

**Thoracic limb**

**Radial, ulnar, musculocutaneous, and medial
block**—The use of a radial, ulnar, musculocutaneous,
and medial block was first described by Trumpatori et al.\textsuperscript{61} This was a landmark-based technique. Complete nerve block of the 4 nerves was obtained in only 1 out of the 16 injected. The first ultrasound-guided clinical use was described in a report by Portela et al.,\textsuperscript{62} in which the authors successfully used it in a surgical resolution of a carpal luxation. Its execution is well described by Portela et al.\textsuperscript{63} This block targets the radial nerve as it crosses over toward the lateral aspect of the midhumerus, and the musculocutaneous, medial, and ulnar nerves located in the medial aspect of the midhumerus (Figure 5). A slight variation in the execution was published by Otero et al\textsuperscript{64} in which blockade of all the nerves was executed from the lateral aspect. This is an effective block in patients undergoing radius and ulna surgery and carpal surgery such as carpal arthrodesis. Deficits will be observed at the level of the carpus; however, shoulder and elbow motor function will be generally well maintained. Patients will be unable to extend or flex the carpus for 8 to 12 hours, although shoulder and, in most cases, the elbow motor function will be preserved. In some cases, and depending at what level this block is executed, motor function of the elbow will be lost; however, as shoulder function will be maintained, patients will be able to maintain sternal recumbency.

Spinal surgery

Erector spinae block—Erector spinae (ESP) block is one of the newest and latest fascial plane infiltrations to be implemented in veterinary species. First described by Ferreira et al.\textsuperscript{25} it aims to deposit the local anesthetic in between the multifidus and longissimus muscles or between multifidus, longissimus, and iliocostalis muscles, depending on the approach, in direct contact with lamina where the dorsal branch of the relevant spinal nerves run. No injectate migration to the ventral branches or sympathetic trunk has been observed in any of the cadaveric studies published to date.\textsuperscript{24} However, epidural space migration in 2 out of 17 cadavers was reported by Medina-Serra et al.\textsuperscript{65} The infiltration at this level will selectively and segmentally distribute along the dorsal branches (medial and lateral) of the spinal nerves\textsuperscript{66} and thus block the paraspinal muscles, laminae and facets,\textsuperscript{67} making it especially interesting for spinal surgery. So far, the ESP block is showing promising clinical results when used as part of a multimodal approach in thoracolumbar hemilaminectomies.\textsuperscript{68} The dog reported by Zannin et al.\textsuperscript{69} did not need any rescue analgesia during the first 12 hours postoperatively. Portela et al.\textsuperscript{69} published a retrospective cohort study looking at 114 records of dogs undergoing hemilaminectomy, 42 dogs with ESP block, and 72 with opioid-based analgesia. Preoperative block was associated with lower intra- and postoperative opioid administration, a reduced incidence of complications such as postoperative vomiting or regurgitation requiring treatment, and a shorter time to return to voluntary feeding. Two cases of sinus arrest have been reported. In both cases, a previous hemilaminectomy had been performed and therefore epidural or even spinal local anesthetic migration had a high probability of being the cause. Both dogs recovered uneventfully. Additionally, a letter to the editor has been published recently regarding the use of an ESP block as an analgesic technique in a case of acute pancreatitis.\textsuperscript{70}
Closing thoughts

As in today, one of the main barriers to implement locoregional anesthetic techniques into routine practice and ERAS protocols, not only in veterinary but also in human medicine, is the lack of training and expertise among clinicians in general and anesthesiologists in particular. This, we believe, is changing rapidly with the current expansion of e-learning, training bootcamps, and the efforts of some professional associations such as the New York School of Regional Anesthesia in the human field and the American College of Veterinary Anesthesia and Analgesia and the European College of Veterinary Anesthesia and Analgesia in the veterinary arena. Collaborations between human health-care providers (anesthesiologists) and veterinary anesthesiologists help our profession stay at the forefront.

Figure 5—A—Relevant ultrasound anatomy pertinent to the radial, ulnar, musculocutaneous, and median nerve block. The marker (green circle) is oriented cranially. The radial nerve can be observed in between the brachialis, lateral, accessory, and medial heads of the triceps. The goal is to first advance the needle into the medial aspect of the radial nerve and administer the first aliquot of local anesthetic. Secondly, the needle should be redirected and advanced towards the brachial neurovascular sheath where the brachial vessels, musculocutaneous, median, and ulnar nerves can be found. Following verification of a negative aspiration test, a second aliquot of local anesthetic should be administered in this location. Expansion of the neurovascular sheath should be observed during the injection. B—Ultrasound-guided radial, ulnar, musculocutaneous, and median nerve block being carried out on a Beagle dog. The dog is positioned in lateral recumbency with the limb to be blocked positioned uppermost. A high-frequency, linear array ultrasound transducer should be positioned on the lateral aspect of the brachial arch, over the triceps muscle, in a transverse orientation related to the ipsilateral humerus and with the marker (green circle) oriented cranially. The needle should be advanced in plane. *Brachial artery. BM = Biceps femoris muscle. H = Humerus. MCN = Musculocutaneous nerve. MN = Median nerve. RN = Radial nerve. TAH = Triceps muscle accessory head. TLH = Triceps muscle lateral head. TMH = Triceps muscle medial head. UN = Ulnar nerve. See Figure 2 for remainder of key.

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References

7. Kalamaras AB, Aarnes TK, Moore SA, et al. Effects of perioperative saphenous and sciatic nerve blocks, lumbo-


