Short Communication

Anatomical Surgical Landmarks in Canine Thoracolumbar Surgery: A Cadaveric Study

Toni-Björn Breuer [1,2,*], Tibor Németh [2] and Franck Forterre [1]

[1]Division of Small Animal Surgery, Department of Clinical Veterinary Medicine, Vetsuisse Faculty, University of Bern, 3012 Bern, Switzerland
[2]Department of Small Animal Surgery and Ophthalmology, University of Veterinary Medicine Budapest, 1077 Budapest, Hungary
*Corresponding author: toni-bjoern.breuer@unibe.ch

ABSTRACT

Thoracolumbar surgeries in canines have become increasingly important in veterinary surgery, requiring precise anatomical knowledge to accurately identify the site of the lesion during surgery. This accuracy is crucial to minimize the risk of wrong-site spinal surgeries (WSSS). This study aims to identify reliable and practical anatomical landmarks in the thoracolumbar region. In addition to existing landmarks and imaging techniques, the identified landmarks may aid surgeons in safely orienting themselves during operative procedures and ensuring the correct surgical site during the surgical approach. Nine cadavers were examined. After thawing, dissections were performed to identify anatomical landmarks between the tenth thoracic and first lumbar vertebrae. Additionally, the intercristal line has likewise been investigated as landmark caudal to the thoracolumbar region. Mammillary processes were palpable at T12-T13 and most prominent at T13-L1. The facet joints displayed a horizontal orientation at T10-T11 and a vertical caudo-dorsal, better palpable orientation at T11-T12. The spinalis and semispinalis musculature are consistently inserted into the mid-layer of the thoracolumbar fascia at the level of T11. The tendons of the lumbar longissimus attached to the L1 accessory process. The intercristal line consistently marked the L6-L7 interspinous space across all specimens. These landmarks provide practical intraoperative guidance for thoracolumbar surgeries. This study provides less-known anatomical structures to the currently known and used landmarks, supporting their use for preoperative planning and intraoperative navigation. Combining these anatomical findings with digital imaging techniques may enhance surgical accuracy and therefore reduce the risk for WSSS.

Keywords: Canine anatomy; Surgical landmarks; Thoracolumbar surgery; Wrong-site spinal surgery.

INTRODUCTION

Thoracolumbar surgeries in canines have become increasingly important in veterinary surgery, offering effective treatment for a wide range of spinal conditions affecting the thoracic and lumbar regions (Jeong et al. 2019; Olby et al. 2022; Brechbühl et al. 2024). Comprehensive anatomical knowledge is essential for surgeons to evaluate intraoperative landmarks to locate lesions accurately. These landmarks, which include bony structures such as spinous processes, articular facet joints, transverse processes, and costovertebral articulations, as well as muscular structures like epaxial muscle insertions, aid in ensuring safe and reproducible intraoperative assessments (Brisson 2023; McCartney et al. 2024).

Intervertebral disc disease (IVDD) is a prevalent spinal condition in dogs, affecting approximately 2% of clinical patients (Boursier et al. 2018; Fenn and Olby 2020; Brechbühl et al. 2024). Over 85% of the lesions occur at the discs between the eleventh and twelfth thoracic vertebra (T11-T12), and second and third lumbar vertebra (L2-L3) (Sharp and Wheeler 2005; Pontikaki et al. 2022). Chondrodystrophic breeds are particularly predisposed to IVDD due to anatomical anomalies such as elongated backs and miniaturization. Furthermore, obesity also increases the risk from routine activities like climbing stairs or jumping (Packer et al. 2013; Brown et al. 2017; Olby et al. 2022).

Accurate localization of the diseased vertebrae is critical for successful thoracolumbar surgery, yet wrong-site spinal surgery (WSSS) remains a concern. In human medicine, reported rates range from 0.03% to 5.2% (Palumbo et al. 2013; Boursier et al. 2018; Shah et al. 2020).

A prospective veterinarian study has shown that the thoracolumbar region has a higher chance of incorrectly marking the exact site for surgery (McCartney et al. 2024). Medical records in two veterinary hospitals showed over a 4-year period the occurrence of wrong-level spinal surgery in 1.28% of the cases (Boursier et al. 2018). WSSS can either occur on the wrong level or on the wrong side (Epstein 2021; McCartney et al. 2024). To minimize these errors, various human medical studies recommend thorough anatomical knowledge, preoperative and intraoperative imaging, and precise spine level identification (Vitale et al. 2018; Epstein 2021). Techniques such as percutaneous palpation, needle placement, ultrasonography and intraoperative fluoroscopy have been proposed to enhance surgical accuracy, though their effectiveness varies (Noussitou et al. 2017; Boursier et al. 2018; Vitale et al. 2018; Epstein 2021).

In human medicine, the intercristal line is a commonly used landmark, which can be palpated, to identify the lumbar spine levels, indicating L4 and L5 interspinous space (Tantri et al. 2022).

Trying to address an obvious lack of veterinary literature dealing with the topic, this descriptive study of nine cadaveric canine specimens investigated consistent and practical anatomical surgical landmarks in the thoracolumbar region, spanning from the tenth thoracic vertebra to the first lumbar vertebra. Additionally, the intercristal line has been likewise investigated as a potential landmark caudal to the thoracolumbar region, identifying L6 that could be used by counting back the spinous processes towards the thoracolumbar region. In addition to existing landmarks and imaging techniques, the identified landmarks may aid veterinary surgeons in safely orienting themselves during operative procedures.

MATERIALS AND METHODS

Cadaver study

For this study, nine canine cadavers were used, which had been euthanized for reasons unrelated to the present study. The cadavers were provided by the Department of Anatomy and Histology, University of Veterinary Medicine, Budapest, and handled following the university's cadaver handling regulations. The carcasses were grouped according to their weight: below 10, between 10 and 25, and above 25kg. Each dissected group consisted of three dogs, including one French Bulldog, one Shar Pei, and seven mixed-breed dogs.

Dissection

The dogs were stored frozen and then thawed at room temperature for the dissection. All nine cadavers were skinned by anatomical technicians and placed in a ventral recumbent position. The spinous processes of T11 and L1 were identified and marked using hypodermic needles. This was achieved by palpating the last rib, T13, the sacrum, and L7, followed by cranial counting of the spinous processes. An incision at the lumbosacral region confirmed the correct positioning of L7.

Forceps were used to mark L6 and L7 in relation to the intercristal line. After identifying and incising the thoracolumbar fascia, the spinalis and semispinalis and lumbar longissimus musculature were exposed. The

tendinous insertion of the spinalis and semispinalis muscle at the mammillary processes were further dissected and the origin of the multifidus muscle could be appreciated. Throughout the dissection, the positions of the mammillary processes and facet joints, as well as the relationship between L6, L7 and the intercristal line were assessed.

RESULTS

Bony landmarks

The mammillary process is superimposed on the cranial articular process of the lumbar vertebrae, forming the mammillo-articular process. Cranial to the thoracolumbar transition, this process shifts towards the cranial portion of the transverse process (Evans and de Lahunta 2013). The mammillary processes were first palpable at T12 during dissection but were most prominent at T13 and L1, where they were easily palpated in all nine specimens. The difference between the transverse process of L1 and the last rib was evaluated. The last rib was seen slanting caudally in comparison to the relatively short transverse process of L1, which inclined cranially, and the tip of the transverse process could be palpated more profoundly than the last rib.

During dissection, the facet joint between T10 and T11 was found to be horizontally oriented, while the T11–T12 joint was more vertically aligned and more prominent to palpate, with a caudo-dorsal orientation of the joint surfaces, as visible in Fig. 1. The most cranial accessory process, which can be palpated in the thoracolumbar region, is the one from T12. It reaches over the intervertebral foramen of T12-T13. The accessory process of T13 is also more prominent than T12.
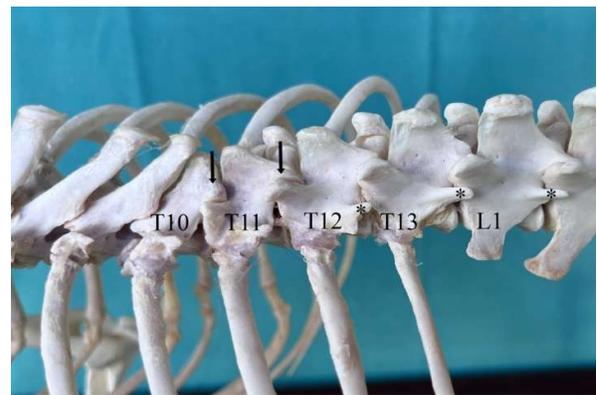

Fig. 1: Dorsolateral view of the facet joints. The joints of T10-T11 and T11-T12 are marked with arrows. The accessory processes are marked by asterisks.

The intercristal line consistently passed through the interspinous space between L6 and L7 in all cadavers, as seen in Fig. 2.

Soft tissue landmarks

In all nine dissected cadavers, the spinalis and semispinalis musculature were inserted into the middle layer of the thoracolumbar fascia at the level of T11. As seen in Fig. 3, upon opening this layer, tendons originating from these muscles were visible, inserting into the mammillary processes. The originating multifidus muscle,

which inserts into the cranially lying spinous process could also be well exposed. The lumbar longissimus musculature had medial tendons inserting at the accessory process of L1 to L6. Among these, the insertion at the accessory process of L1 was particularly well-defined during dissection.
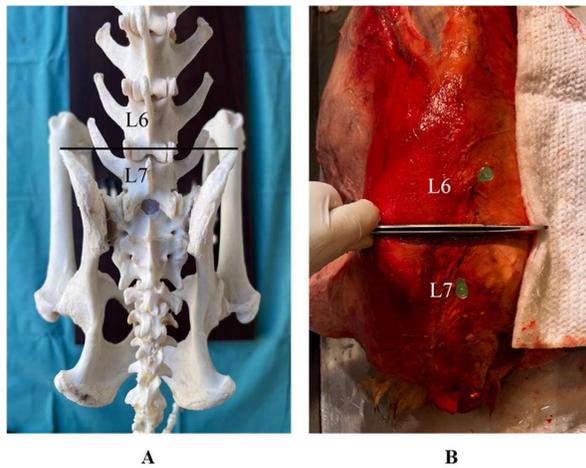
Fig. 2: Dorsal view of the lumbosacral region. (A) Spinous processes of L6 and L7 are marked in blue. The line indicates the intercristal line. (B) Spinous processes are marked with hypodermic needles.
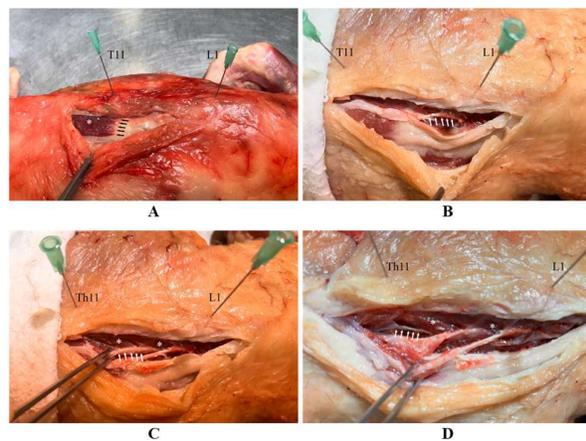
Fig. 3: Dorsolateral view of the lumbosacral region. The hypodermic needles mark the spinous processes of T11 and L1. (A) Arrows indicate the insertion of the spinalis and semispinalis musculature into the mid-layer of the thoracolumbar fascia. Arrows indicate tendons inserting at the mammillary process of (B) L1, (C) T13, and (D) T12. The asterisks in (C) and (D) mark the multifidus muscles.

DISCUSSION

Accurate intraoperative orientation is critical for a successful thoracolumbar surgery and for preventing WSSS. Our cadaveric dissections identified consistent bony and soft-tissue landmarks that may support safer surgical navigation in dogs. To the author's knowledge, this is the first veterinary study to describe the anatomical surgical landmarks systematically. Especially the mid lumbar region lacks reliable landmarks, and therefore, more cranial or caudal landmarks will be used for orientation in these cases. That is why this study's main focus was the thoracolumbar region from T10 to L1 and secondarily the caudal lumbar region, based on the findings of McCartney et al. (2024). Due to the absence of the intercapital ligament, the former region represents the majority of IVDD cases (Sharp and Wheeler 2005; Brisson 2010; Caruso et al. 2025).

Currently used surgical landmarks for preoperative orientation include identification of T13 and counting caudally or using the iliac crest to find L7 and counting cranially; their accuracy ranges from 76.6% to 87.5% (Noussitou et al. 2017; Boursier et al. 2018). Preoperative marker placement, such as with use of sterile needle, remains common in veterinary practice, as it is simple to perform and inexpensive (Chin et al. 2017). The placement can then be verified by dorsolateral radiographs, fluoroscopy, or computed tomography. However, the accuracy decreases further from the iliac crest, particularly in obese dogs (Noussitou et al. 2017). It has also been suggested to use Backhaus clamps to mark the intended surgical site, as they do not tend to move in comparison to needles (McCartney et al. 2024).

The anticlinal vertebra, typically the first vertebra without a caudally slanting spinous process, is often used intraoperatively as a reference point (Evans and de Lahunta 2013). However, its position can vary and therefore should be assessed by imaging prior to the surgery (Baines et al. 2009). During dorsolateral approaches, the spinous processes are only partially exposed, limiting their reliability. In such cases, alternative landmarks may offer more practical intraoperative guidance. For example, distinguishing the transverse process of L1 from the 13th rib can provide orientation (Sharp and Wheeler 2005).

In our dissections, several additional landmarks demonstrated greater consistency and surgical applicability. The facet joints offered reliable palpatory landmarks. The T10-T11 joint was comparatively small and horizontally aligned, whereas the T11-T12 joint was larger with a distinct caudodorsal orientation, making it more readily palpable during dissection. This provides surgeons with a reproducible intraoperative landmark in the cranial thoracolumbar region, particularly valuable during dorsolateral approaches.

The intercristal line also proved reliable, consistently intersecting the interspinous space between L6 and L7 across all dissected cadavers. This makes it a practical caudal reference point for counting cranially towards the thoracolumbar region. Although its utility may be limited in obese patients where palpation is difficult, it represents a promising adjunct for preoperative orientation. While our cadaveric findings suggest consistency, radiographic studies in larger and more diverse clinical populations are required to confirm their reliability before routine application.

During dorsolateral approaches, the accessory processes may additionally aid in orientation, particularly in mini- or hemilaminectomies (Brechbühl et al. 2024). The accessory process of T12 is the most cranial consistently identified, though it is less prominent than that of T13 and L1.

Soft tissue structures further support orientation, with the spinalis and semispinalis muscles inserting consistently into the thoracolumbar fascia at T11, and the lumbar longissimus muscle attaching to the accessory process of L1. The

muscular insertions were easily recognized during dissections and could provide valuable intraoperative guidance, especially when exposure of bony landmarks is limited.

The importance of WSSS has not yet been fundamentally studied, despite IVDD being one of the most common neurological disorders (Moore et al. 2020; McCartney et al. 2024). The incidence in veterinary medicine has been described in one report to be 1.28% (Boursier et al. 2018). Multiple factors can contribute to the occurrence of WSSS, such as misinterpreting the radiographs, misplaced percutaneous markers and anatomical variations. The risk is especially increased in obese patients (Boursier et al. 2018; McCartney et al. 2024).

It is suggested that the error of WSSS is made during the surgical incision into the skin (McCartney et al. 2024). However, the use of intraoperative anatomical surgical landmarks can aid the surgeon to realize the error prior to performing, for instance, the hemilaminectomy, and to ensure the correct site. WSSS can cause structural damage, prolonged surgery time, and increased postoperative recovery time (Palumbo et al. 2013; Boursier et al. 2018; McCartney et al. 2024). By providing reproducible anatomical landmarks, our findings may help surgeons to ensure the correct surgical site and potentially reduce the risks.

This study has several limitations. Radiographs were not obtained prior to the dissections; therefore, anatomical abnormalities, such as missing ribs, vertebrae, or transitional vertebrae, could not be ruled out, which could have influenced our results. However, after complete dissection of the cadavers, no gross skeletal anomalies were observed. The sample size was small, with nine dogs and limited to a single chondrodystrophic breed, though a high prevalence of thoracolumbar malformations in brachycephalic breeds has been reported (De Decker et al. 2024). Due to the deskinning of the cadavers prior to dissection, any palpation findings may also have been altered, and sex-related variation was not assessed. Finally, the intercristal line was evaluated only by palpation in a limited sample size; therefore, further radiographic validation in a larger population is necessary to validate the practicability.

Conclusion

This descriptive anatomical study identifies consistent but previously underemphasized surgical landmarks that can aid during pre- and intraoperative orientation in the canine thoracolumbar region. These include the intercristal line, the orientation of T10-T12 facet joints, the accessory processes, and the insertion of the spinalis and semispinalis muscle and lumbar longissimus muscle. While these landmarks may help reduce the risk of wrong-site spinal surgery, they cannot replace careful preoperative planning and verification. Combining multiple approaches, such as palpation, percutaneous markers, or intraoperative imaging, remains advisable, with anatomical landmarks serving as a complementary guide to ensure accurate localization during surgery.

DECLARATIONS

Conflict of Interest: The authors declare no conflict of interest.

Data Availability: Data are available at request from the corresponding author.

Ethics Statement: Ethical approval was not required for this study, as it involved cadaveric specimens in accordance with local legislation and institutional guidelines. The animals were euthanized for reasons unrelated to the study.

Author's Contribution: Conceptualization, T.-B.B. N.T. and F.F.; methodology, T.-B.B. and F.F; investigation, T.-B.B.; data curation, T.-B.B.; writing—original draft preparation, T.-B.B.; writing—review and editing, T.-B.B., N.T. and F.F.; visualization, T.-B.B..; supervision, N.T. and F.F.; All authors have read and agreed to the published version of the manuscript.

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