ULTRASONOGRAPHIC IMAGING OF THE VENTRAL ABDOMINAL MIDLINE (VAM) OF FEMALE DOGS

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SUMMARY

Thirty adult, female canine cadavers of different breeds were used to observe the images created from old incision sites ultrasonographically. A real time B-mode ultrasound scanner equipped with a high resolution 7.5 MHz linear array transducer was used to examine the ventral abdominal midline (VAM). A block of muscle sample approximately two centimetres square was taken after scanning for light microscopic examination. Ultrasound can be used to determine whether the animals had had an earlier operation on the VAM. Ultrasound could also differentiate between the normal VAM, the VAM with a new incision site, and the VAM with an old incision site. However, it could not determine the age of the surgical site exactly.

Keywords: ultrasonography, cadavers, ventral abdominal midline (VAM)

INTRODUCTION

Ultrasonography can be used to detect subtle differences in acoustic impedance of soft tissue and, therefore, is a sensitive technique for locating and characterizing fluid collection and masses (Christensen *et al.*, 1988). The development of a haematoma and of fibrous scars can be followed up by ultrasonography, but it is not possible to determine the point of time after injury very accurately (Kullmer *et al.*, 1997). Ultrasonography has been shown to be useful in defining mass location, lesion margins and tissue of origin, lesion tissue characteristics, invasion into nearby blood vessels and oesophagus, and the optimal location for directing needle aspiration or tissue biopsy (Fornage *et al.*, 1983).

The present study was carried out with the aim of evaluating the use B-mode ultrasound to observe the images created from old incision sites.

MATERIALS AND METHODS

The animals and preparation technique

Thirty adult, female canine cadavers of different breeds which had been euthanased for other reasons within 24 hours were used in this study. The ventral abdominal area were examined physically prior to scanning. The cadavers were placed in dorsal recumbency. The hair was removed from the level of xyphoid cartilage to the level of pubic brim using clippers. Ultrasound gel was then applied prior to scanning to give the best contact between the transducer and the skin.

Ultrasonographic examination

Scanning was done in a semi-dark room. Prior to examination, the scanner was calibrated, the gain settings for near field, mid field and overall were adjusted for each scan. The scanning was done transversely across the ventral abdominal mid-line with the transducer head held perpendicular to the linea alba as illustrated in Fig. 1.

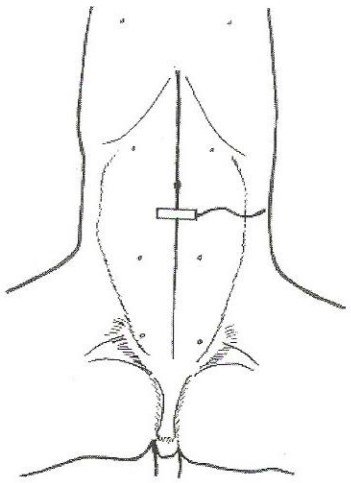

Fig. 1. Illustrated diagram demonstrating the technique of VAM scanning. the scanning is done transversely across the VAM from the xyphoid cartilage to the pubic brim.

The transducer was then moved slowly and firmly along the ventral abdominal mid-line from cranial to caudal. In some cases, a sonolucent stand-off pad was used.

A real time B-mode ultrasound scanner (Capasee, TOSHIBA) equipped with a high resolution 7.5 MHz linear array transducer was used in this study. The ultrasound machine was connected to a video recorder (Panasonic) during each scanning session and a high quality video tape (super VHS) was used to record the images. The recorded images were reviewed at a later date using an Interspec

(Apogee-cx) ultrasound machine. Thermal copies of the best images were printed during the review and labelled.

Histological preparation

After each examination, a sample block of muscle approximately two centimetres square was taken from each cadaver from the area of approximately 3-5 centimetres caudal to the umbilicus depending on the size of the animal. The muscle sample were then put in 10% formalin for histologic examination. The tissue samples were sectioned and processed for haemotoxylin and eosin as previously described by Lendrum *et al.* (1962) and Culling, (1974).

RESULTS

The summary of' the ultrasonographic and histological examination of the ventral abdominal mid-line in 30 cadavers is shown in Table 1. For the purpose of this study, the ultrasonographic appearance of the ventral abdominal mid-line (VAM) has been divided into three groups: group one represent the VAM with the presence of a new incision site, group two represent the VAM with the presence of an old incision site, and group three represent the normal VAM (without any sign of incision site). Out of 30 cadavers examined ultrasonographically, 8 (26.7%) were found to have a normal VAM, 5 (16.7%) were found to have a new incision site, and 17 (56.7%) were found to have an old incision site.

Normal VAM

A normal VAM was found in nine cadavers. Ultrasonographic appearance of the normal VAM was constant Fig. 2). It appeared isoechoic relative to the muscle tissue. No area of altered echogenicity was found along the VAM or in adjacent rectus abdominis muscle. The rectus abdominis muscle imaged ultrasonographically appeared as an homogenous hypoechoic structure and was obviously enveloped by the hyperechoic connective tissue fascia, the perimysium. Histologically, no evidence of scar tissue formation was found in the muscle adjacent to the VAM.

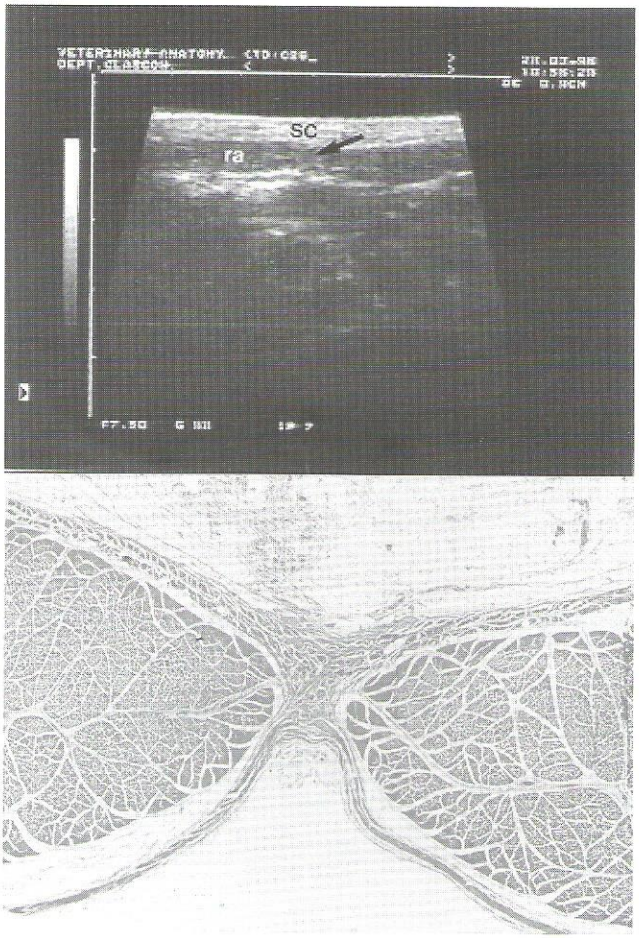

Fig. 2. Transverse scan of normal VAM caudal to the umbilicus in cadaver 6. The VAM appears isoechoic relative to muscle tissue. The subcutaneous tissue appears hyperechoic relative to muscle tissue. Note also that rectus abdominis muscle is surrounded by the hyperechoic connective tissue fascia, the perimysium. Histologically, there is no scar tissue found. sc, subcutaneous tissue, ra, rectus abdominis muscle.

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Table 1. Summary of ultrasonographic and microscopic findings on VAM caudal to the umbilicus

No. of cases	Ultrasonographic findings	Microscopic findings
8	Normal muscle characteristic. Subcutaneous tissue appears more echogenic in 5 cases, isoechoic in 2 cases and less echogenic in one case relative to muscle.	No evidence of scar tissue formation.
5	An ill-defined hypoechoic area. Subcutaneous tissue appeared more echocenic in 4 cases and less echogenic in one case relative to muscle.	Area of high inflammatory cells. Suture materials still present in 2 cases.
17	Area of increased echogenicity within muscle in 14 cases and area of ill-defined disorganized hypoechoic structure in 3 cases. Subcutaneous tissue appeared more echogenic than muscle in 14 cases, less echogenic in 2 cases and isoechogenic in one case.	Area of scar tissue formation within muscle. High level of fat lobules around scar tissue in 3 cases.

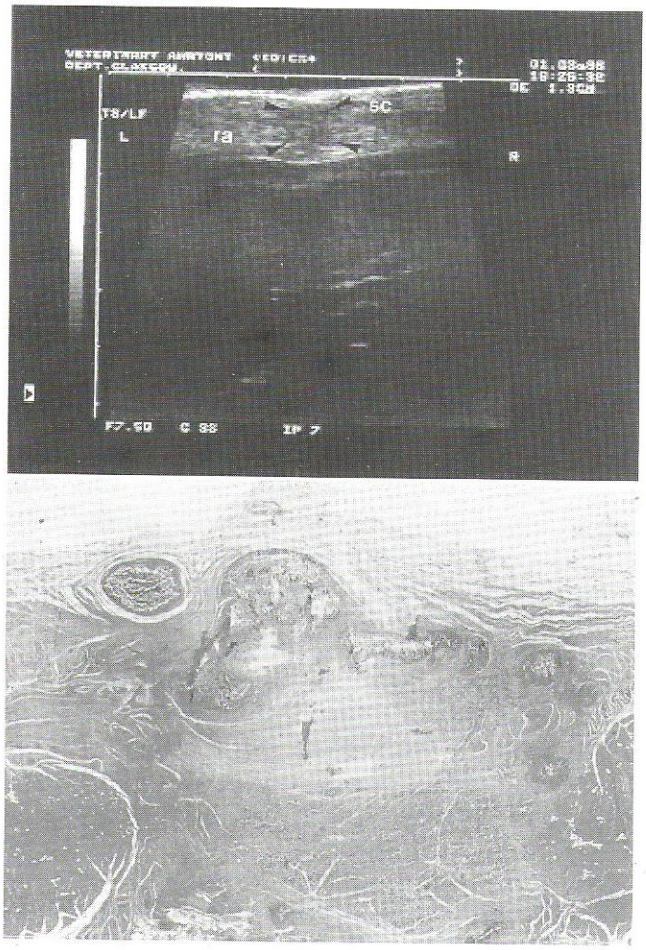

Fig. 3. Transverse scan of VAM caudal to the umbilicus with the presence of new incision site in cadaver 4 demonstrates a disorganized hypoechoic area with an ill-defined margin at the VAM. Histologically, there is an area of inflammatory cell accumulation at the VAM which corresponds to the hypoechoic appearance on ultrasound. The subcutaneous tissue appears isoechoic relative to the muscle tissue. sc, subcutaneous tissue, ra, rectus abdominis muscle.

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VAM with a new incision site

Ultrasonographic examination of the VAM with the presence of new incision site revealed a disorganized area with ill-defined margins which was hypoechoic relative to the surrounding tissue Fig. 3). The VAM had lost its normal isoechoic appearance. Histologically, there was an accumulation of high number of inflammatory cells at the VAM which corresponded to the hypoechoic area. In cadaver 18, ultrasonographic examination revealed an hypoechoic area in the subcutaneous tissue superficial to the rectus abdominis muscle (Fig. 4). Histologically, there was an area of inflammatory cells accumulating in the subcutaneous tissue which correspond to the hypoechoic area on ultrasound. In cadaver 21, some blood was still present during examination and the suture material was still intact. Ultrasonographic examination revealed an ill-defined disorganised hypoechoic area, casting acoustic shadowing artefact (Fig. 5). In this animal the subcutaneous tissue appeared hypoechoic relative to the muscle structure. There was also fluid accumulation in the subcutaneous tissue as shown by the anechoic area.

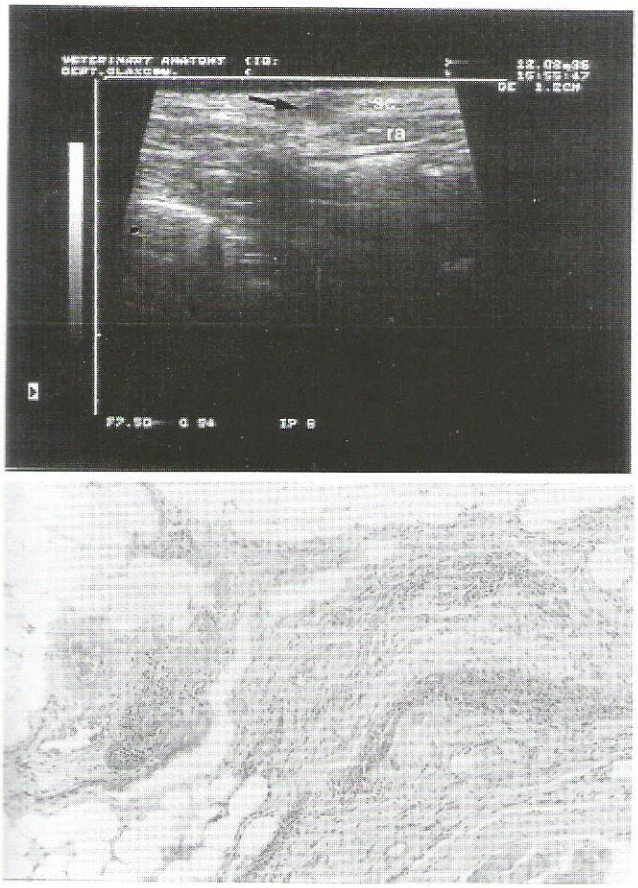

Fig. 4. Transverse scan of VAM in cadaver 18 with the presence of new incision site demonstrates an hypoechoic area within the subcutaneous tissue (arrow) just above the VAM. Histologicaly, there is an area of inflammatory cell accumulation in the subcutaneous tissue which is responsible for the hypoechoic appearance on ultrasound. sc, subcutaneous tissue, ra, rectus abdominis muscle.

Histological examination was not carried out in this case because the block of muscle proved difficult to process.

VAM with an old incision site

The majority of the cadavers examined (17) fell into this group. Ultrasonographic appearance of the VAM with the presence of an old incision site varied from hypoechoic to hyperechoic. Most of them appeared as an ill-defined disorganized hyperechoic area relative to its surrounding (Fig.s 6). These hyperechoic areas corresponded to the areas of scar tissue formation on histological examination. In three cadavers (7, 11 and 28), the VAM appeared as poorly disorganized hypoechoic structure relative to the surrounding tissue Fig. 7). Histological examination revealed a high level of fat lobules around the scar tissue which was believed to be responsible for the hypoechoic appearance on the ultrasound image.

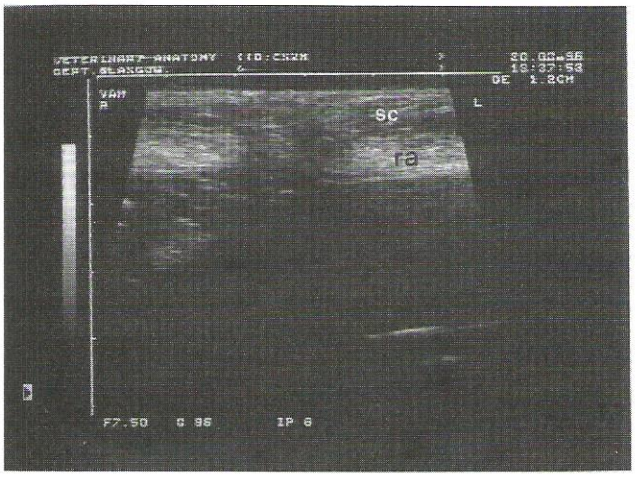

Fig. 5. Transverse scan of the VAM with fresh incision site in cadaver 21 demonstrates a disorganized homogenous hypoechoic area with acoustic shadowing artefact at the incision site. Note also that the subcutaneous tissue appears hypoechoic reative to the muscle tissue. sc, subcutaneous tissue, ra, rectus abdominis muscle.

In three cases (14, 22 and 30), the incision site appeared almost isoechoic to the surrounding muscle (Fig. 8). Histological examination revealed a small number of fat lobules around the scar tissue. The subcutaneous tissue superficial to the rectus abdominis muscle and just under the skin had variable appearance ultrasonographically. It appeared from hypoechoic to hyperechoic relative to the muscle tissue. Of the 30 cadavers scanned in this study, 19 cadavers demonstrated subcutaneous tissue with hyperechoic appearance, seven cadavers demonstrated isoechoic appearance and the remaining four cadavers demonstrated a hypoechoic appearance. Skin appeared as a hyperechoic layer. The fascia of dense connective tissue enveloping the rectus abdominis muscle appeared hyperechoic on ultrasound.

DISCUSSION

An old injury with scar tissue formation can be differentiated by high resolution ultrasonography (Gerwing and Kramer, 1995). Careful comparison of both sides of an animals may reveal an echogenic area in a tendon that represent a scar or incomplete tear (Wilson, 1988). Results of this study show that the ultrasonographic appearance of scar tissue within the muscle varied from hypoechoic to hyperechoic. Therefore, to differentiate between the scar tissue and normal muscle texture, the scanned image must be

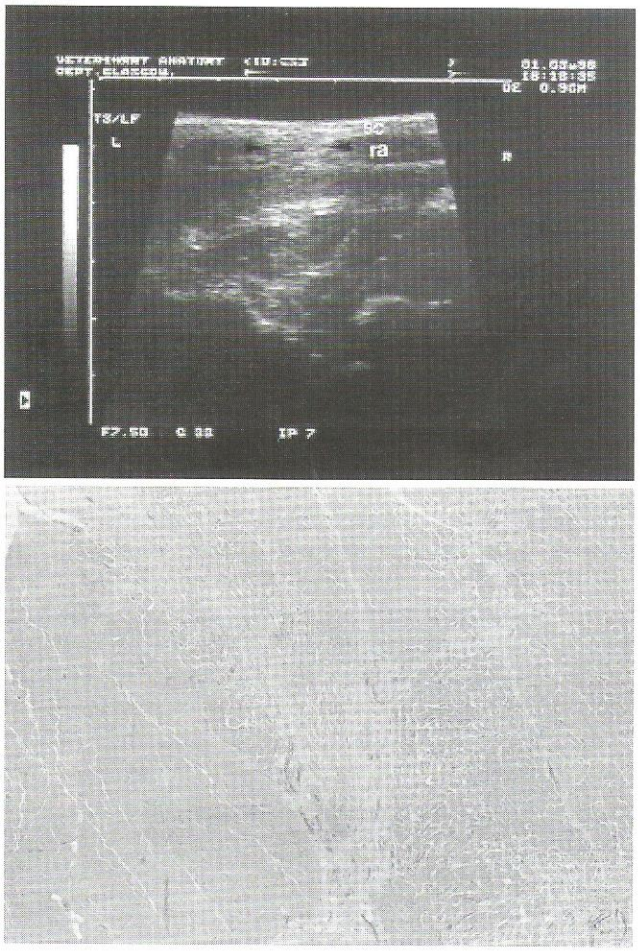

Fig. 6. Transverse scan of the VAM with the presence of an old incision site demonstrates an hyperechoic area relative to the surroundings (arrow heads). Histologically, there is scar tissue formation on both sides of the rectus abdominis muscle adjacent to the VAM. Note also the subcutaneous tissue appears hyperechoic relative to muscle tissue. sc, subcutaneous tissue, ra, rectus abdominis muscle.

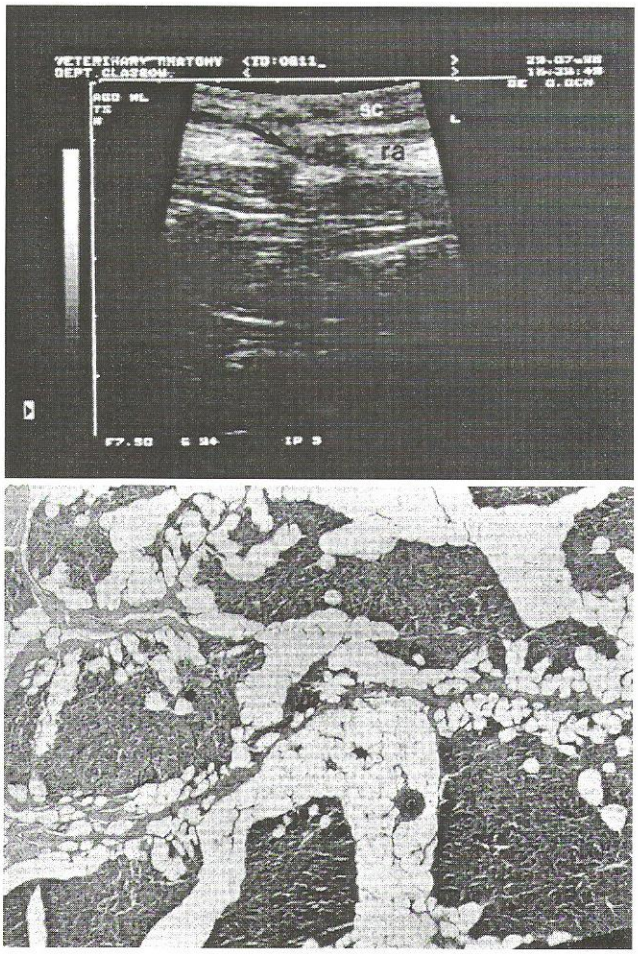

Fig. 7. Transverse scan of the VAM in cadaver 11 with the presence of an old incision site demonstrates a disorganized hypoechoic area (arrow). Histologically, there is scar tissue formation (arrows) found in the muscle with a high level of fat lobules around. Note also that the subcutaneous tissue appears hypoechoic relative to the muscle tissue in this animal. sc, subcutaneous tissue, ra, rectus abdominis muscle.

observed carefully. Ultrasonographic appearance of the scar tissue is however, thought to depend on the stages of the scar tissue formation (Wilson, 1988).

Ultrasonogarphic image of new scar tissue formation with the presence of a high number of inflammatory cells on histological examination appeared as an disorganized hypoechoic area with an ill-defined margin relative to the surroundings. This is an accord with Laine *et al.* (1985) who demonstrated an hypoechoic area in a human hamstring muscle after partial rupture which had healed within 8 to 9 weeks. This hypoechoic area was suggested to be due to formation of new collagen fibres. In this study, the hypoechoic area of the new incision site corresponded to the area of a high number of inflammatory cells on microscopic examination. Thus, the result suggests that an inflammatory area within muscle or subcutaneous tissue gives an hypoechoic appearance on ultrasonographic image. Old scar tissue formation has been reported to have an hyperechoic appearance (Laine *et al.*, 1985). Similarly, in this study scar tissue formation within muscle without the presence of high fat lobules appeared hyperechoic relative to the surrounding tissues.

Most of the old incision sites with the presence of scar tissue imaged ultrasonographically appeared as disorganized hyperechoic areas relative to the surrounding muscle. However, in some animals the old incision site appeared as a hypoechoic or isoechoic structure relative to the surroundings. This discrepancy seemed to depend on the amount of fat lobules present around the scar tissue. The higher the level of fat lobules around the scar tissue the less echogenic it became. The results are in accord with Laine *et al.* (1985) who reported that the image of scar tissue (fibrosis) in muscle gives a variable hyperechoic structure. There is a direct relationship between the echoic intensity and the amount of collagen (Henry *et al.*, 1986). In this study, the scar tissue with a higher

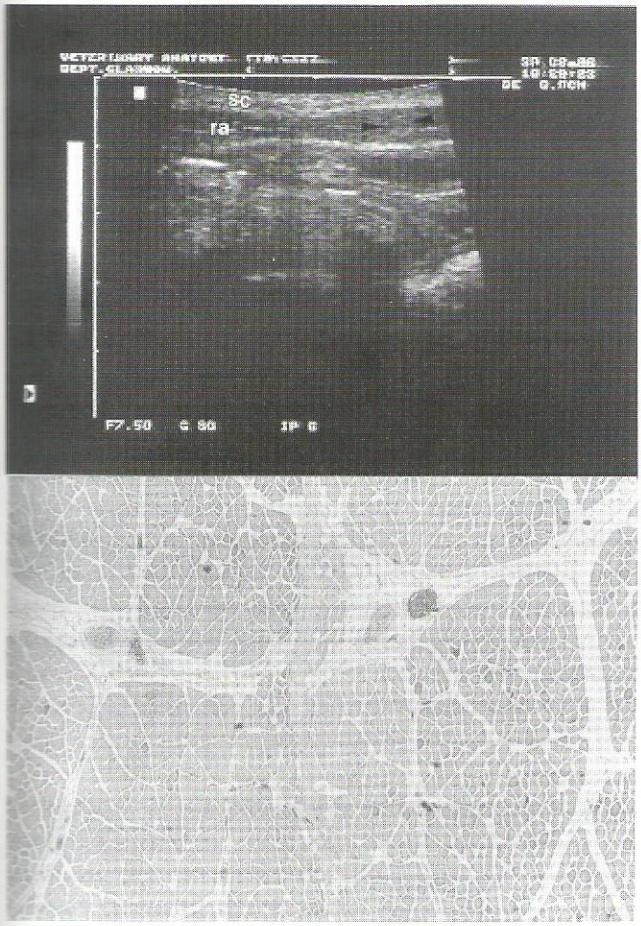

Fig. 8.Transverse scan of the VAM caudal to umbilicus in cadaver 22 with the presence of an old scar tissue demonstrates slightly hyperechoic area (almost isoechoic) relative to the surroundings (arrow heads). Histologically, there is a presence of scar tissue formation (arrows) in the muscle with little fat lobules. Note also the subcutaneous tissue appears hyperechoic relative to the muscle tissue. sc, subcutaneous tissue, ra, rectus abdominis muscle.

proportion of fat lobules around the scar on microscopic examination corresponded to the area of disorganized hypoechoic or isoechoic structures on ultrasound. Thus, the ultrasonographic appearance of the VAM with an old incision site in this study depended on the amount of fat lobules around the scar tissue as demonstrated histologically. This was probably due to the sound beam being largely absorbed by the fat lobules, and therefore the sound reflection was less. The amount of fat tissue decreasing as healing progresses together with improving orientation of regenerating muscle fibres made the ultrasonographic differentiation between normal and healing muscular tissue become more difficult (Lehto and Alanen, 1987).

The presence of suture material within the muscle in three cases (4,12 and 18) except in case 21, suggested that the surgery was done within a few weeks of euthanasia. In normal circumstances, the common absorbable suture material used to closed the muscle layer is surgical gut (catgut) and this is absorbed by the body within seven days (Vasseur, 1985). In these animals, ultrasonographic findings were constant. The images revealed an ill-defined hypoechoic area which corresponded to the area of increased inflammatory cells on microscopic examination.

Studies in the human demonstrated that subcutaneous tissue is generally more echogenic than muscle (Yeh, 1985; Kaplan *et al.*, 1990). In some circumstances the subcutaneous tissue appeared poorly echogenic especially in obese patients (Vincent, 1988; Kaplan *et al.*, 1989). In this study, the subcutaneous tissue was found to have variable appearances. However, the majority of cases appeared more echogenic than muscle. Thus, the result suggested that the subcutaneous tissue in dogs imaged ultrasonographically had a variable appearance.

Findings in this study also show that the majority of the ventral abdominal surgical incisions made in the animals within this study were not exactly on the VAM. Most of the incisions were made in the rectus abdominis muscle adjacent to the VAM. This study also found that the reason for having ventral abdominal surgery done on animals was not necessarily only for ovariohisterectomy purposes. This is because in some cadavers with the presence of an hyperechoic area when imaged along the VAM caudal to the umbilicus and with the presence of scar tissue formation microscopically, the uterus and ovary were still intact. Thus, this suggested that the surgery had been done for some other reason.Thus searching for a surgical site with ultrasound could be a useful tool to decide whether a bitch has undergone an ovariohisterectomy but it could not preclude that the animal had undergone surgery for some other reason.

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REFERENCES

Christensen, R.A., Sonnenberg, E.V., Casola, G. and Wittish, G.R. (1988). Interventional ultrasound in the musculoskeletal system. *Radiology Clinics North America* **26**:145-156

Culling, C.L.A. (1974). Handbook of histopathology and histochemical techniques. 3rd ed.

Fornage, B.D., Touche, D.H., Segal, P. and Rifkin, M.D. (1983). Ultrasonography in the evaluation of muscular trauma. *Journal of Ultrasound in Medicine* **2**:549-554

Gerwing, M. and Kramer, M. (1995). Sonographical findings of muscle diseases in dogs and cats. *Veterinary Radiology & Ultrasound*. **36**: 437

Henry, G.A., Patton, C.S. and Goble, D.O. (1986). Ultrasonographic evaluation of iatrogenic injuries of the equine accessory (carpal check) ligament and superficial digital flexor tendon. *Veterinary Radiology* **27**:132-140

Kaplan, P.A., Anderson, J.C., Norris, M.A. and Matamoros, A. (1989). Ultrasonography of post traumatic soft tissue lesions. *Radiologic Clinics of North America* **27**:973-982

Kaplan, P.A., Matamoros, A. and Anderson, C. (1990). Sonography of the musculoskeletal system. *American Journal of Roentgenology* **155**:237-245

Kullmer, K., Sievers, K.W., Rompe, J.D., Nagele, M. and Harland, U. (1997). Sonography and MRI of experimental muscle injuries. *Arch Orthopaedic and Traumatic Surgery* **116**:357-361

Laine, H., Harjula, A., and Peltokallio, P. (1985). Experience with real time sonography in muscle injuries. *Scandinavian Journal of Sports Science* **7**: 45-49

Lehto, M. and Alanen, A. (1987). Healing of a muscle trauma: correlation of sonographical and histological findings in an experimental study in rats. *Journal of Ultrasound Medicine* **6**:425-429

Lendrum, A.C., Fraser, D.S., Sliddes, W. and Henderson, R.C. (1962). Histological and histochemical techniques. *Journal of Clinical Pathology* **15**:401-409.

Vasseur, P.B. (1985). Principle of operative surgery. In: General Small Animal Surgery, by Gourley, I.M. and Vasseur, P.B. (eds.). Philadelphia: J.B. Lippincott, pp 75-104

Vincent, L.M. (1988). Ultrasound of soft tissue abnormalities of the extremities. *Radiologic Clinics of North America* **26**:131-144

Wilson, D.J. (1988). Diagnostic ultrasound in the musculoskeletal system. *Current Orthopaedics* **2**:41-50

Yeh, H.S. (1985). Ultrasonography of orthopedics and soft tissues extremities. In: Sanders R.C., Hill M.C. (eds.) *Ultrasound annual* 1985. New York: Raven.

RINGKASAN

IMEJ ULTRASONOGRAFI GARISAN TENGAH VENTRAL ABDOMEN (VAM) ANJING BETINA

Tiga puluh bangkai anjing betina berbagai spesis telah digunakan bagi memerhati imej yang di hasilkan oleh bekas luka yang lama melalui ultrasonografi. Mesin ultrabunyi masa-sebenar mod-B yang dilengkapi dengan transdusi resolusi tinggi 7.5 Mz telah digunakan bagi memeriksa garisan tengah ventral abdomen (VAM). Sampel otot bersaiz lebih kurang 2 sm persegi telah diambil selepas setiap pemeriksaan ultrabunyi untuk pemeriksaan histologi. Ultrabunyi boleh digunakan bagi menentukan samada haiwan itu telah melalui pembedahan atau pun belum pada bahagian VAM. Ultrabunyi juga boleh membezakan di antara VAM yang normal, VAM dengan kesan pembedahan yang baru, dan VAM dengan kesan pembedahan yang lama. Walaubagaimanapun, ultrabunyi tidak dapat menentukan dengan tepat berapa lama pembedahan telah dilakukan.