Gross anatomy and ultrasonographic examination of the reproductive organs in rams and bucks

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Abstract

Breeding soundness examination (BSE) of rams and bucks is performed by veterinarians as a service for producers to help identify males that may not be capable of settling females early in the breeding season and sire offspring with the genetic potential for rapid and efficient growth. In the routine BSE, palpation of the testis cannot assess with accuracy testicular parenchyma and presence of small lesions. Ultrasonography and testicular biometric parameters are a better approach for evaluation of the testes. In addition, testicular ultrasonography can be a important tool for the evaluation of scrotal circumference and testicular volume and prediction of fertility potential. To provide a basis for this BSE, this paper presents a detailed overview of the anatomy of ram and buck reproductive system and outlines the basis for ultrasonographic examination of the genital tract. Common and uncommon ultrasonographically visible lesions of the scrotum and its content including abnormalities of the various testicular envelops, the spermatic cord, the testicular parenchyma, the epididymis and the internal genitalia are described and illustrated.

Keywords: Ram, buck, breeding soundness examination, genital tract, anatomy, ultrasonography.

Anatomie et examen échographique des organes génitaux chez le bélier et le bouc

Résumé

L'examen de l'aptitude à la reproduction (EAR) des géniteurs réalisé par les vétérinaires permet d'identifier dès le début de la saison de reproduction, les mâles qui seraient capables de fertiliser des femelles. Ces mâles sont supposés garantir la production de descendants porteurs d'un potentiel génétique qui assure une croissance rapide et efficace. Lors de la réalisation d'un EAR de routine, la palpation du testicule ne permet pas d'évaluer avec précision l'état du parenchyme testiculaire et de détecter la présence de petites lésions. L'échographie et la détermination des paramètres biométriques testiculaires constituent une meilleure approche pour l'évaluation de l'état sanitaire des testicules. En outre, l'échographie testiculaire peut être un outil précieux pour l'évaluation de la circonférence scrotale et du volume testiculaire et pour la prédiction du potentiel de fertilité. Le présent article présente en détail l'anatomie du système reproducteur du bélier et du bouc, et décrit ensuite les bases de l'examen échographique du tractus génital. Les lésions échographiquement visibles du scrotum et son contenu, y compris les anomalies des différentes enveloppes testiculaires, le cordon spermatique, le parenchyme testiculaire, l'épididyme et les organes génitaux internes y sont détaillées et illustrées.

Mots-clés: Bélier, bouc, examen de reproduction, tractus génital, anatomie, échographie.

INTRODUCTION

Domestic small ruminants have an important potential of reproduction due to their high fertility and prolificacy rates. Their breeding is preferred by a large number of farmers with low incomes. Intensive and pastoral farming systems success depend on livestock management especially improvement of reproductive performances. Both male and female genital systems have to be sound to ensure successful breeding. Ram and buck breeding soundness examination is important to assess the ability of impregnating females during the breeding season. Physical and ultrasonographic examinations are essential to detect problems that may interfere with the reproductive function.

This paper presents an overview of the anatomy of ram and buck reproductive system and highlights the importance of their ultrasonographic examination. It also presents the ultrasonographically visible lesions of the various portions of the genital tract.

GROSS ANATOMY OF THE REPRODUCTIVE ORGANS IN RAMS AND BUCKS

Similarities of the reproductive organs exist between rams and bucks, even though some morphological variations are present. The reproductive tract of these species (Figure 1A) consists of the testes, the accessory sexual glands, and the spermatic pathways responsible for semen transport and its deposition in the female genital tract.

The testes

The testes ensure the production of spermatozoa (spermatogenesis) and synthesize testosterone, which is the main reproductive hormone in males. Testicular descent and migration through the inguinal canal begin early in both the ram and the buck, between the 100th and the 105th day of fetal life. The final disposition is acquired before the fifth month of gestation. Failure of normal testicular

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descent results in cryptorchidism. Retained testicles are not capable of spermatogenesis. Different arguments are in favor of a hereditary cause of failed testicular migration. Cryptorchid males should be culled from the breeding program (Tibary *et al.*, 2018).

The testes are housed in their bursa outside the abdominal cavity so as to be maintained at a temperature of 3 to 5°C below body temperature. This slight hypothermia is essential for spermatogenesis. However, very low temperatures may jeopardize spermatogenesis. The protection provided by the bursa and the cremaster muscle retraction of the testis close to the abdominal cavity constitute the main mechanisms for maintaining testicular temperature close to that of the body. Similarly, high temperatures (fever, heat stress) may reduce fertility.

In the ram and the buck, the testes are located in the inguinal region. They are attached to the body by the spermatic cord, which includes blood vessels, nerves and the vas deferens. The spermatic cord enters the abdominal cavity through the inguinal canal. In both species, the long axis of the testis is vertical; the *extremitas capitata*, is dorsal while the epididymal edge is in medial position. The ram and buck testis are oval and elongated. The mature testis weight varies depending on genetic and environmental factors. Season affects testicular weight as well as sperm quantity and quality (Ortavant *et al.*, 1988; Tibary *et al.*, 1988). In general, the testis weight varies between 170 g and 250 g in rams and between 130 g and 160 g in bucks (Barone, 1978).

Basic conformation of ram and buck testis shows two smooth lateral and medial surfaces, an anterior convex free edge (*margo liber*), the epididymal edge (*margo epidymidis*) which is less convex and located in front of the caudal part (Figures 2B, 2C, 3). The *extremitas capitata*, is continuous with the anterior head of epididymis (caput). The *extremitas caudate* which is circumvented by the tail of the epididymis represents the opposite pole.

Testicular Structure

Testicular structure is formed by fibrous layers, especially the albuginea and the main testicular tissue, the *parenchyma testis* (Figures 1D, C, F). The *albuginea* sends radiations (*Septula testis*) which form lobules that contain the seminiferous tubules. The radiations of the *septula testis* converge in the central part of the testis to a longitudinal connective tissue that extends from the top to the bottom of each testis constituting the *mediastinum testis*. At this level, the seminiferous tubules lead to the collecting ducts constituting the *rete testis*. The latter conducts the spermatozoa to the head of the epididymis. The seminiferous tubules are divided into two types: convoluted tubules, which are numerous and constitute the main location of spermatozoa and straight tubules ending in the *rete testis*. Seminiferous tubules are made up of spermatogenic cells and sustentacular cells known as Sertoli cells. Spermatozoa are formed through a long process of cell division and maturation. In the loose connective tissue between the seminiferous tubules, there are specialized testosterone-producing cells, the Leydig cells.

Testicular bursa

The testes are housed within a testicular bursa, which comprises 7 envelopes (Figure 2). The main function of the bursa is to protect and support the gonads, the first spermatic pathways (epididymis and the beginning of the vas deferens) and the vessels of the spermatic cord.

The scrotum is the first and superficial envelope. Its nature is cutaneous and common to both testes. However, some buck breeds such as Somali goats have a "*split scrotum"* with two scrotums, one for each testis (Girma, 2008). The scrotum is thick and covered with rough hair in the buck, thinner and woolly, except partially the dorso-cranial area in the ram.

The dartos is the second envelope, which is intimately connected to the scrotum. It is a yellowish connective tissue forming an envelope for each gonad and extends up to the superficial inguinal ring (*annulus inguinalis superficialis*).

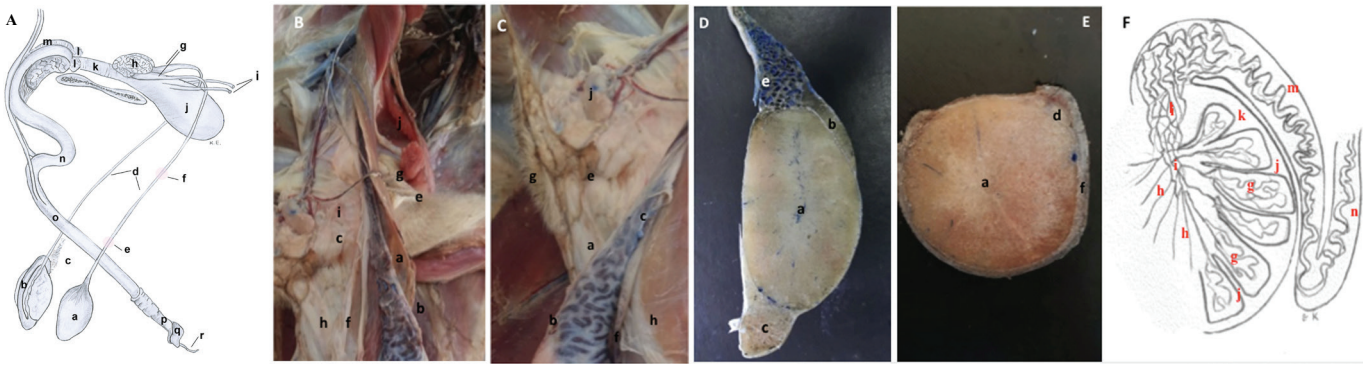

Figure 1: Gross anatomy of the reproductive organs in rams and bucks. (A): Overview of genital organs of the mature ram (a): testis, (b): epididymis, (c): plexus pampiniformis; (d): deferent duct; (e): superficial inguinal ring; (f): deep inguinal ring; (g): ampulla of the deferent duct; (h): vesicular gland; (i): ureter; (j):bladder; (k): intrapelvial urethra with urethral muscle; (l): bulbourethral gland; (m): bulbo spongious muscles; (n): sigmoid flexure; (o): average part of the penis; (p): neck of glans; (q): glans; (r): urethral process. (B) and (C): Photographs showing the basic conformation of testis in the ram. Arteries were injected and plasticized using a mixture of 10% formalin solution, gypsum powder and ultramarine blue pigment (PB29). (a): medial surface; (b): free edge; (c): epididymal edge; (d): lateral surface; (e): extremitas capitata; (f): extremitas caudate; (g): head of epididymis; (h): tail of epididymis; (i): body of epididymis; (j): plexus pampiniformis. (D), (E) and (F) : Internal conformation and testicular structure. D &E: longitudinal and transversal sections of buck testicle after injection and plasticizenation of arteries with a mixture of 10% formalin solution, gypsum powder and ultramarine blue pigment (PB29). F : gross section of testis of the buck (a): mediastinum testis ; (b): head of epididymis; (c): tail of epididymis; (d): body of epididymis; (e): plexus pampiniformis; (f): testicular bursa; (g): seminiferous tubules; (h): straight tubules; (i): rete testis; (j): septum; (k): tunica albuginea; (l): efferent ducts; (m): epididymis; (n): deferent duct

The external spermatic fascia (*fascia spermatica externa*) constitutes the third envelope. It has two thin fibrous layers protecting the testes. Their sliding allows the testicle to move easily under the skin in case of compression or shock. This layer is the most frequent site of pathological infiltrations in this area.

The cremaster muscle, a dependence of the internal oblique muscle, is made of striated muscular fibers located at the caudal surface of the internal spermatic fascia and barely reaches the level of the *extremitas capitata* of the testicle.

The internal spermatic fascia (*fascia spermatica interna*) is the fourth envelope, which is a fibrous lining of the parietal layer of the vaginal tunic.

The parietal and visceral layers of the vaginal tunic constitute the sixth and the seventh envelopes. The parietal layer is intimately connected to the internal spermatic fascia and the visceral layer surrounds the *tunica albuginea* and closely coats the testis, the epididymis and the spermatic cord. The two layers are linked by the mesorchium.

The testicular artery, which supplies the testis, presents tight and numerous convolutions in close contact with the venous network of the pampiniform plexus (Figures 1A, 1B, 1C) and constitute together the vascular cone of the spermatic cord. This particular layout of the vessels is involved in the cooling process of the arterial blood before its arrival at the testis.

The spermatic pathways

The spermatic pathways include the epididymis, the vas deferens, the urethra and the accessory glands. The epididymis is located caudally to the testicle. Its main role is to ensure the storage and maturation of the spermatozoa. Its head receives the efferent canaliculi from the rete testis and continues through the vas deferens. The latter crosses the inguinal canal in the spermatic cord to reach the pelvic part of the urethra where it opens through a common ejaculatory duct with the corresponding seminal vesicle. The vas deferens of the ram and the buck measures approximately 6 to 7 cm long and 6 to 7 mm wide (Barone, 1978). The pelvic urethra receives the opening of the ejaculatory ostium and the excretory ducts of the accessory glands while the extrapelvic part is incorporated into the penis.

There are three auxiliary or accessory sex glands (Figure 3): the seminal vesicles (or vesicular glands), the disseminated part of the prostate gland and the bulbourethral glands.

The seminal vesicles are located on each side of the urethra, near the end of each vas deferens. The duct of the seminal vesicles and the *ductus deferens* share a common ejaculatory duct that opens into the urethra. Seminal vesicles are pair of compact lobular glands that are easily identified because of their knobby appearance in the ram and buck (Gofur, 2015). They are 3 to 4 cm long and about 2 cm wide (Barone, 1978). They produce the largest fraction of the seminal fluid: about 60 %.

The prostate is characterized by the absence of its conglomerated part in the ram and the buck. Only the disseminated part spreading within the membrane of the pelvic urethra exists in these two species. In the ram, it does not extend to the ventral surface of the urethra, while it surrounds it in the buck (Barone, 1978).

The bulbourethral glands (Cowper) are paired round or oval compact bodies measuring about 1 cm in the ram and the buck and located on the dorsal surface of the intra-pelvic urethra near its exit from the pelvic cavity and in front of the ischiatic arch (Barone, 1978; Muhammad *et al.,* 2016). By eliminating residual urine, the secretion product of these glands gives an optimal environment for spermatozoa when crossing the urethra (Turman and Rich, 1999).

The penis

The ram's and the buck's penis is fibro-elastic and has little erectile tissue (Figure 3A). It measures about 40 cm in length. The root is thick due to the large development of the ischiocavernosus and bulbospongious muscles. The penis glans is particularly voluminous showing at its base a large extension, the urethral process. It is longer in the ram (4 cm) than in the buck (2,5 cm).

Figure 2: Testicular bursa in the ram. Lateral view of the left testicle. Arteries were injected and plasticized using a mixture of 10% formalin solution, gypsum powder and ultramarine blue pigment (PB29). (a): scrotum; (b): dartos; (c): external spermatic fascia; (d): cremaster muscle; (e): internal spermatic fascia with the parietal layer of the vaginal tunic; (f): visceral layer of the vaginal tunic; (g): head of epididymis; (h): tail of epididymis; (i): plexus pampiniformis; (j): testicular arteries branches; (k): superficial venous system of testicle.

The prepuce, which is a cutaneous envelope, conceals the penis when it is flaccid. The body of the penis in these species is characterized by its sigmoid flexure. This is a double curvature of the penis on the median plane, slightly caudal to the scrotum. Erection increases only slightly the length of the penis. It is achieved by the unfolding the sigmoid flexure (Figure 3), which protrudes the free end of the penis out of the prepuce. Retraction of the penis after mating is rapid. It is due to the contraction of two strong retractor muscles of the penis which hold the penis in the "S" shape. These strong muscles contain smooth muscle fibers and originate at the ventral surface of the coccygeal vertebrae.

ULTRASONOGRAPHY OF THE SCROTUM AND ITS CONTENT IN RAMS AND BUCKS

Breeding soundness examination (BSE) includes the assessment for physical soundness, testicular consistency and size, semen quality and mating ability (Tibary *et al.*, 2018). During this examination, particular attention is given to the testes, as they are the site of production of spermatozoa and testosterone. In the routine BSE, palpation of the testis cannot assess with accuracy testicular parenchyma and the presence of small lesions. Ultrasonography is a better modality for evaluation of the testes (Tibary, 2001; Vencato *et al.*, 2014). In addition, testicular ultrasonography can be a precious tool for the evaluation of scrotal circumference and testicular volume and prediction fertility potential (Ugwu, 2009). The technique is a safe, painless and non-invasive. Reflective structures are referred to as being echogenic while the non-reflective ones are referred to as anechoic. Highly reflective structures are termed hyperechoic while structures with low reflections are referred to as hypoechoic (Ragheb and Higgins, 2002).

In small ruminants, ultrasonographic examination of the scrotum and its content is usually performed using a linear array 7.5 MHz or 5 MHz transducer depending on the desired depth (size of the scrotal sac and its content). High frequency transducers (≥7.5 MHZ) offer the advantages of a high resolution and more detailed images, which are suitable for examination of specific areas where lesions are suspected. The epididymis (tail and head) is best visualized with a 7 MHz transducers. Scrotal evaluation using sector transducers has been described (Gouletsou *et al.*, 2003; Gouletsou and Fthenakis, 2010). However, it is not our preferred method unless the scrotum is severely enlarged. Scanning of the scrotum and its content should be done methodically and completely. One approach is to examine each testicle separately starting from the spermatic cord, the head of the epididymis, the testicular parenchyma and finishing with the tail of the epididymis. During the examination, oblique, longitudinal and transverse scans (Figure 4) are made of each section (Tibary, 2001). Because of the difficulty to maintain good contact with the entire scrotum, ultrasonography can be performed using a standoff pad or a water bath (Jeyakumar *et al.*, 2013).

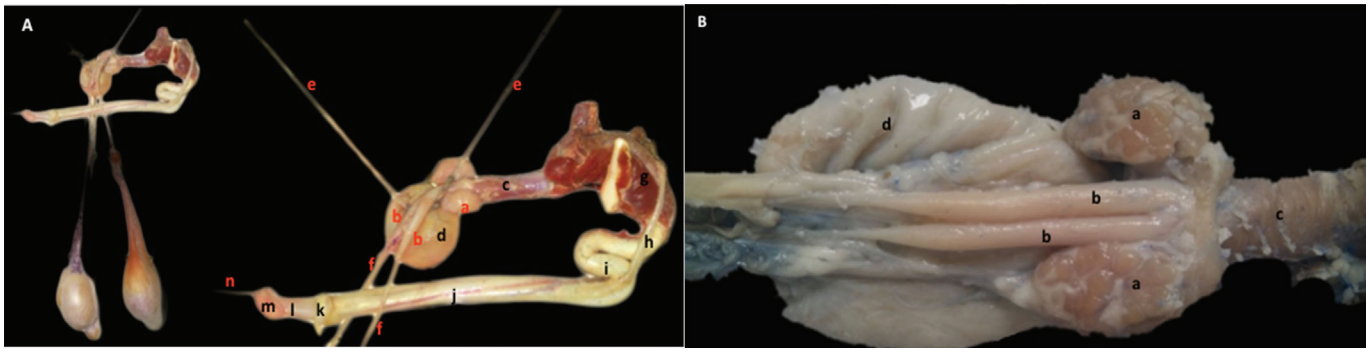

Figure 3: Overview of the genital organs of ram and buck. (A) : lateral view of the genital organs showing the penis of the ram; (a): vesicular glands; (b): ampulla of the deferent; (c): intrapelvial urethra with urethral muscle, (d): bladder; (e): ureter; (f): deferent duct; (g): ischiocavernosus muscle; (h): retractor muscles of the penis; (i): sigmoid flexure; (j): average part of the penis; (k): prepuce; (l): neck of glans; (m):glans; (n): urethral process. (B) Internal part of genital tract showing vesicular glands and the ampulla of the deferent duct of the buck. (a):vesicular glands; (b): ampulla of the deferent; (c): intrapelvic urethra with urethral muscle, (d): bladder

Figure 4: Restraint of the male in a standing position (A) for testes examination and measurements (B). A sitting position (C) or dorsal recumbency (D) can also be used especially in rams

The male is restrained in a standing position by an assistant holding the animal firmly with the two limbs separated such that the testes are freely hanging caudally (Figure 4A,B). Alternatively, the male is set on his rump, and the shoulders pushed down to curve the spine convexly; this makes it easier to protrude the penis (Figure 4C). For elaborate examinations, a dorsal recumbency in a metallic cradle may be used (Figure 4D). It is noteworthy that while these positions are possible with rams, bucks are not amenable to sitting or dorsal position for the exam.

The scrotum should be clipped from wool or hair and thoroughly cleaned before an ultrasound gel is applied generously covering the entire surface. The ultrasound transducer is pressed gently on the surface of the testes. A standard protocol involves viewing the transverse plane (TP) for both testes, the right testis and the left testis; and then on the longitudinal planes (LP) for each testis. The testicular parameters measured are: width of both testes (TW), which is taken on the TP for both testes. This is measured from the most lateral point of the right testis to the most lateral point of the left testis using an electronic caliper. The length of the testis (TL) is taken on the LP and is measured from the most cranial point on the testis to the most caudal point of the testis using an electronic caliper. The height of the testis (TH) is measured by placing the electronic caliper from the highest ventral to the lowest dorsal points of the testes on the LP. The width (TW) is measured as the widest diameter between the lateral and medial aspects of the testes on the TP (Figures 5-8).

The volume of each testis (TV) can be calculated using three different formulae namely the prolate ellipsoid formula (PEF): TL x TH x TW x 0.52 cm^3, the prolate spheroid formula (PSF): TL x TW^2 x 0.52 cm^3 and the Lambert formula (LF): TL x TH x TW x 0.71 cm^3. TV is expressed in cm^3 and represents the average of both testes (Raji *et al.*, 2016). It is important to note that in large breeds, particularly in rams, ultrasonographic measurement of testicular length is difficult due to the size of the testes, which are generally larger than that of the transducer. In such cases, these measures can be done using a standard caliper (Figure 9A,B,C) and TV can be measured using the water displacement technique (Figure 9D).

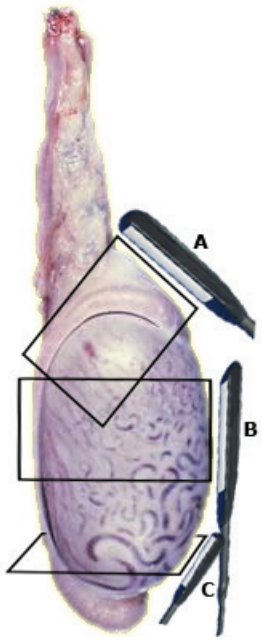

Figure 5: Ultrasonographic examination of the ram testicle with the use of linear probe for oblique (A), longitudinal (B) and transversal (C) scans

In normal rams and bucks, the scrotal skin and testicular envelopes should have a smooth surface. The vascular cone of the spermatic cord is evident with its coiling testicular vessels (Figure 10). The skin and testicular capsule (albuginea) are hyperechoic. The parietal and visceral layers of the *tunica vaginalis* present a decreased echogenicity compared to the skin and albuginea (Figure 11). A small amount of anechoic fluid may be seen in the vaginal cavity. The testicular parenchyma is homogenous and moderately echogenic with a centrally located hyperechoic *mediastinum testis* (Figure 11). Testicular parenchyma and mediastinum testis echogenicity increase with age (Andrade *et al.*, 2014; Carazo *et al.*, 2014). Fluid content of testicular parenchyma increases with increased testosterone and sexual stimulation (Ungerfeld and Fila, 2011; 2012). The head of the epididymis is homogenous and less echogenic compared to the testis (Figure 12). The tail of epididymis is relatively heterogeneous and less echogenic than the testicular parenchyma, and presents

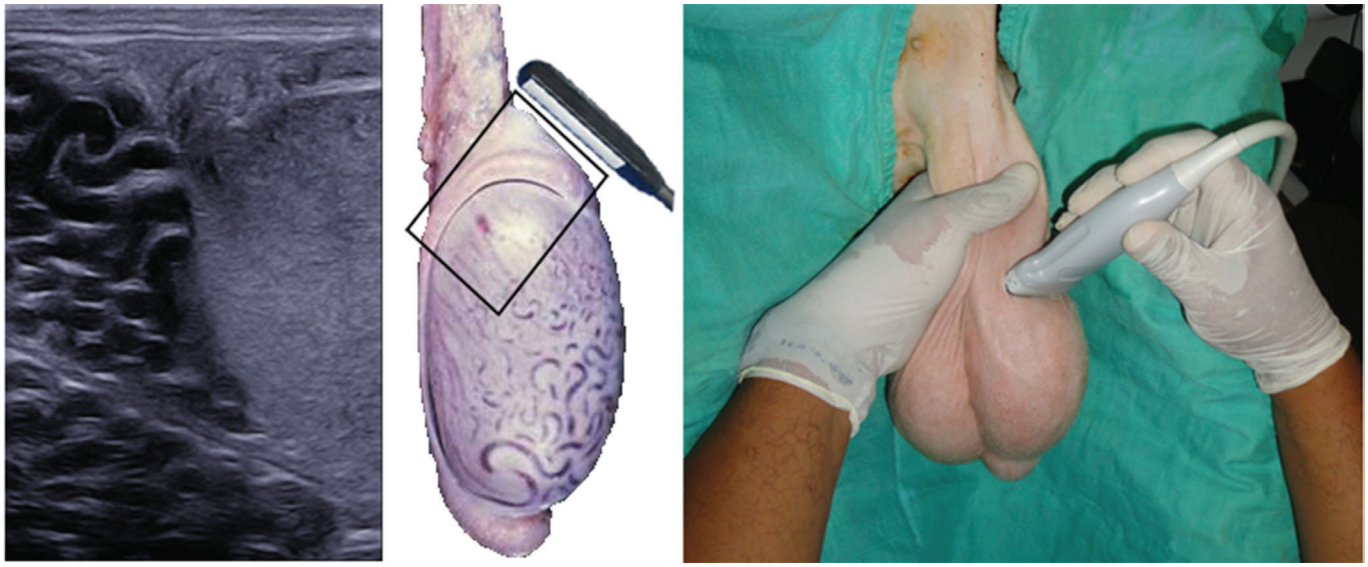

Figure 6: Oblique sagittal cut of the testis at the level of the epididymis head. This scan is clinically important because the pampiniform plexus frequently masks the head of the epididymis during ultrasonographic examination

some anechoic areas (Figure 13) (Ahmad *et al.*, 1991; Karaca *et al.*, 1999; Tibary, 2001). Any deviation from these observations should be taken in consideration and ultrasonographic diagnosis should be combined with other examination data (history, palpation, semen evaluation, and testicular biopsy) for accurate diagnosis of the condition (Ahmad and Noakes, 1995; Ahmad *et al.*, 2000, Tibary, 2001). Advances in development of algorithms for a more refined computer-assisted analysis of epididymal and testicular echotexture may provide a new tool for evaluation of lesions that are not grossly visible and may affect semen quality (Ahmadi *et al.*, 2012). Pixel intensity of testicular parenchyma is affected by age and spermatogenic activity (Chandolia *et al.*, 1997; Giffin *et al.*, 2014; Bartlewski *et al.*, 2017; Giffin *et al.*, 2017).

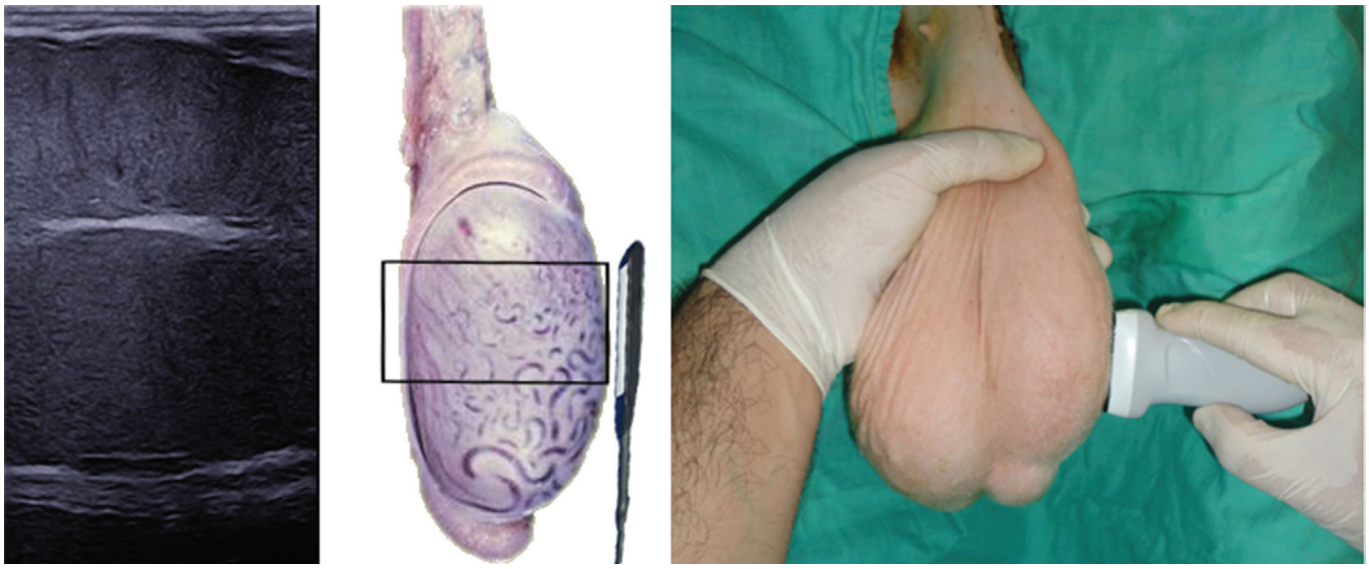

Figure 7: Longitudinal scan of the testis.

Figure 8: Transversal scan of the testes.

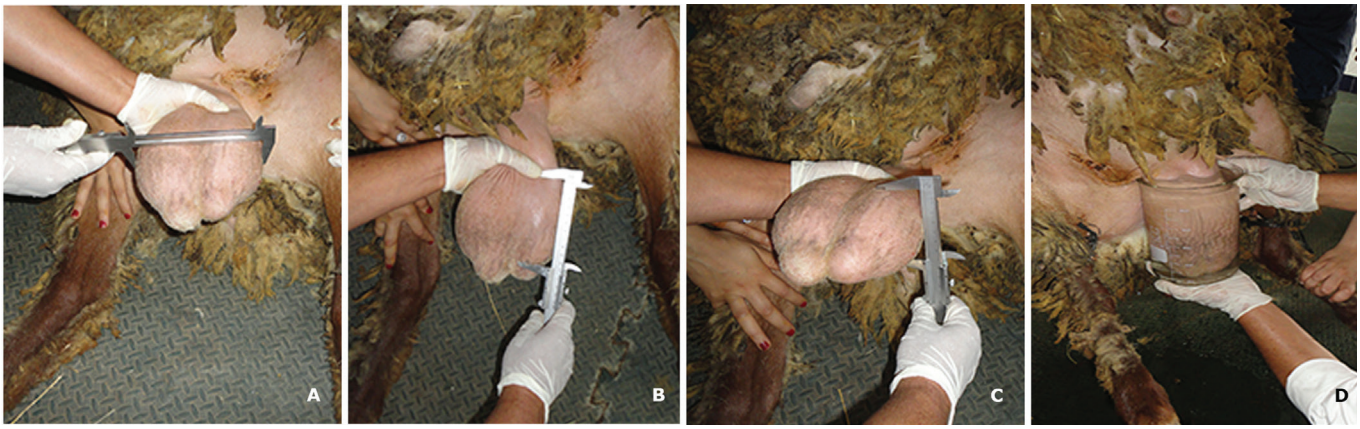

Figure 9: Testicular measurements (width, height, length) using a standard caliper (A,B,C) and testes volume measurement using the water displacement technique (D)

ULTRASONOGRAPHIC CHARACTERISTICS OF SCROTAL AND TESTICULAR ABNORMALITIES

Ultrasonographically visible lesions of the scrotum and its content include abnormalities of the various testicular envelopes, the spermatic cord, the testicular parenchyma and the epididymis. Ultrasonography is an invaluable tool for differential diagnosis of scrotal enlargement. These enlargements may be due to hydrocele, hematoma, abscesses, hernia, pre-orchitis, and orchitis. Scrotal enlargement associated with orchitis and periorchitis shows a thickening of the scrotal wall and various amounts of fibrin and adhesions between the scrotal wall and the testis.

Abnormalities of the scrotum and testicular envelopes

Inflammatory processes such as scrotal abscess and periorchitis cause a loss of the smooth appearance of the affected tissues. In acute events, various degrees of edema and accumulation of fluid may be noted (Figure 14). In chronic cases, the different tissue layers are thickened and may be interspaced by abscesses or fibrosis (adhesions) (Figures 15-16).

Accumulation of fluid within the vaginal cavity is a common finding. The echogenicity of the fluid depends on its nature. In the case of hydrocele, which is the most common, the fluid is anechoic (Figure 17). Hematocele is often encountered in traumatic event and may present as accumulation of fluid with heterogeneous appearance and presence of fibrin. Pyocele is rare and usually has an echogenic appearance (Lacasta *et al.*, 2009b).

In the case of inguinal hernia, the omentum or loops of small intestines may be visible within the scrotal content (Figure 18). A hyperechoic area, corresponding to omental fat within the hernial sac,covers the testis. Anechoic fluid is trapped within a fold of omentum may be visible around the head of the epididymis (Ahmad *et al.*, 2000).

Abnormalities of the spermatic cord

The spermatic cord is very large in small ruminants. The most common abnormalities found in this area are varicocele (Janett and Thun, 1995) and inguinal/scrotal hernia (Lacasta *et al.*, 2009a) (Figure 18). Varicoceles are generally detected by the increased size of the vascular cone. On occasions, we have encountered small abscesses or nodules in the spermatic cord (Figure 19).

Abnormalities of the testis

The most common conditions seen on ultrasonography of the testis are cryptorchidism, orchitis, testicular degeneration, atrophy and mineralization. Location of the testis in

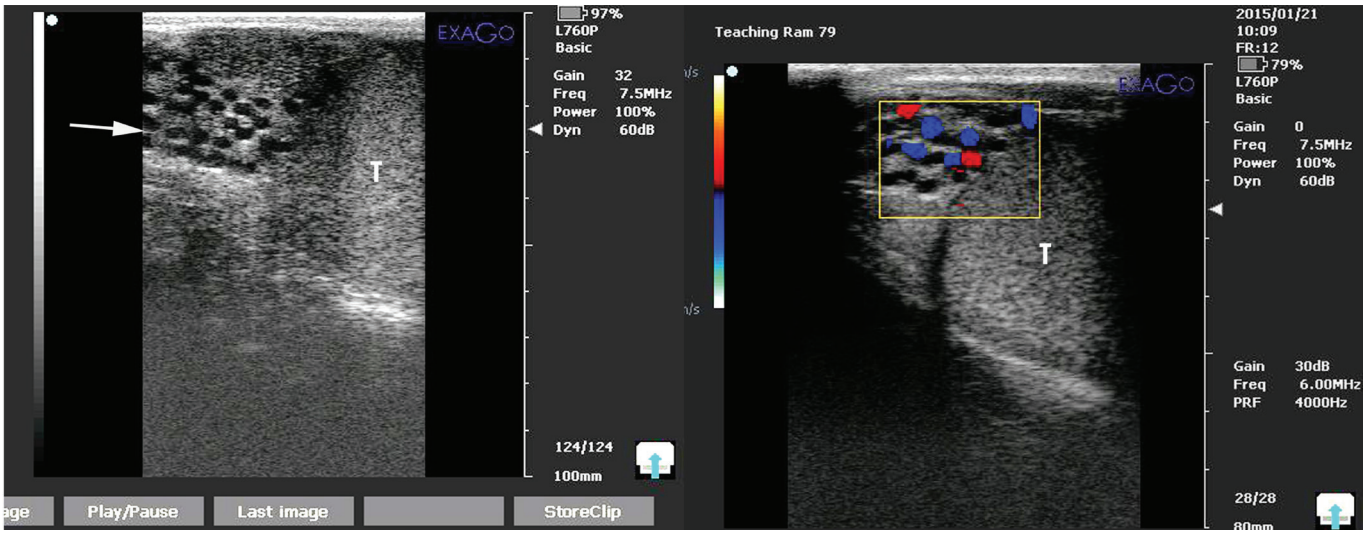

Figure 10: Ultrasonogram of the spermatic cord (arrow) and testicle (T). Right image shows color Doppler image of the testicular artery

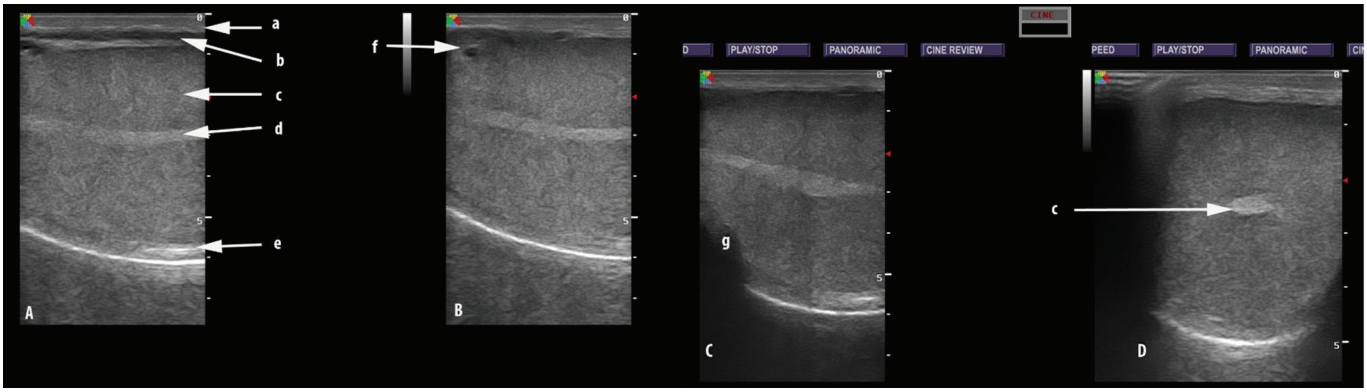

Figure 11: Normal testicular ultrasonogram. A and B, vertical scan showing. a) Skin, b) vaginal cavity, c) testicular parenchyma, d) rete testis, or mediastinum testis, e) albuginea, f) branch of the testicular artery. C) Oblique view showing the head of the epididymis (g), D) cross section of the testis

cases of cryptorchidism can be determined by transcutaneous abdominal/inguinal or transrectal ultrasonography (Kaulfuss, 2006) (Figure 20). The echotexture of the testicular parenchyma is significantly affected by processes inducing testicular atrophy such as immunization against GnRH (Ulker *et al.*, 2005; Ulker *et al.*, 2009). Orchitis is characterized by an increased heterogeneity of the parenchyma (Figure 14). Hypoechoic areas corresponding to abscesses may be seen in specific locations within the parenchyma (Figure 21). In chronic cases, hyperechoic areas are visualized and correspond to areas of fibrosis (Gouletsou *et al.*, 2004). Testicular degeneration and fibrosis are characterized by increased echogenicity of testicular parenchyma (Figure 22). Hyperechogenic and patchy scar tissue areas with single or multifocal mineralized lesions may be seen in some cases (Agumbah *et al.*, 1995; Ahmad and Noakes, 1995) (Figure 23). Accumulation of fluid in the rete testis/mediastinum testis, may be due to spermiostasis (Figure 23).

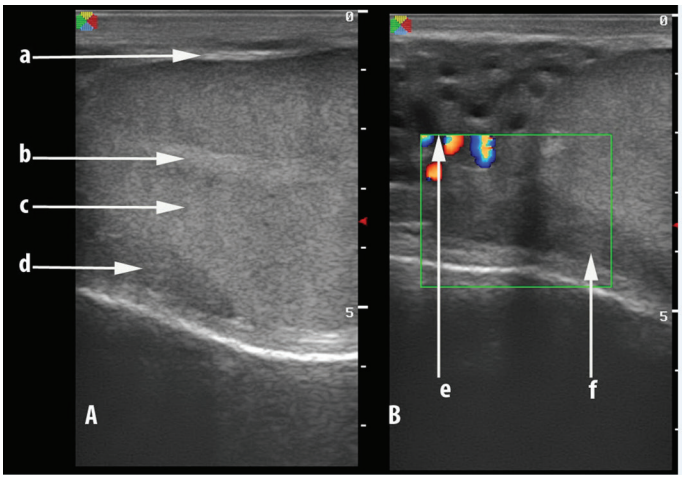

Figure 12: Normal ultrasonogram of the testis and head of the epididymis. Left panel A): a) tunica vaginalis and albuginea, b) rete testis or mediastinum testis, c) testicular parenchyma, d) head of the epididymis. Right panel B: e) testicular artery, f) head of the epididymis

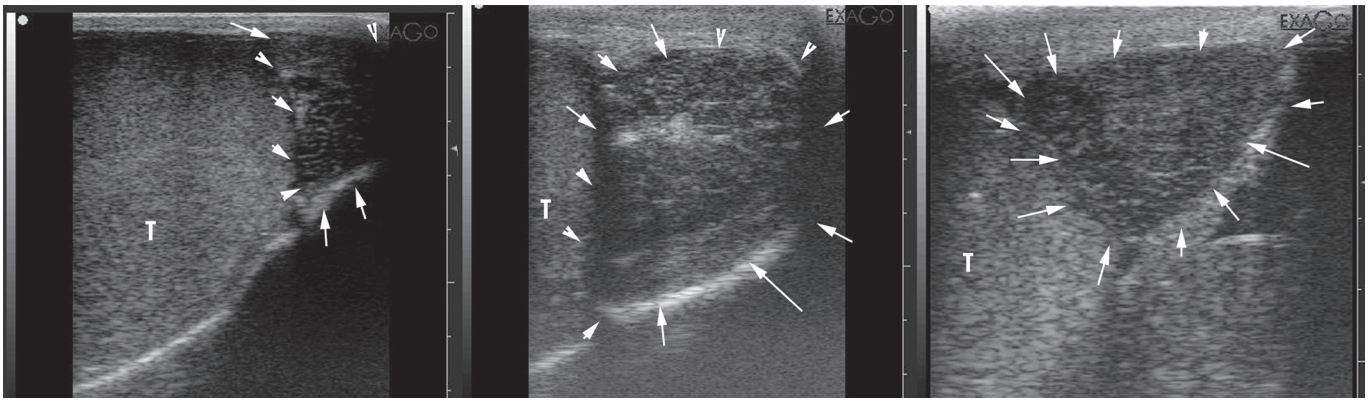

Figure 13: Normal ultrasonogram of the tail of the epididymis (arrows delineate the tail of the epididymis, T= testicular parenchyma)

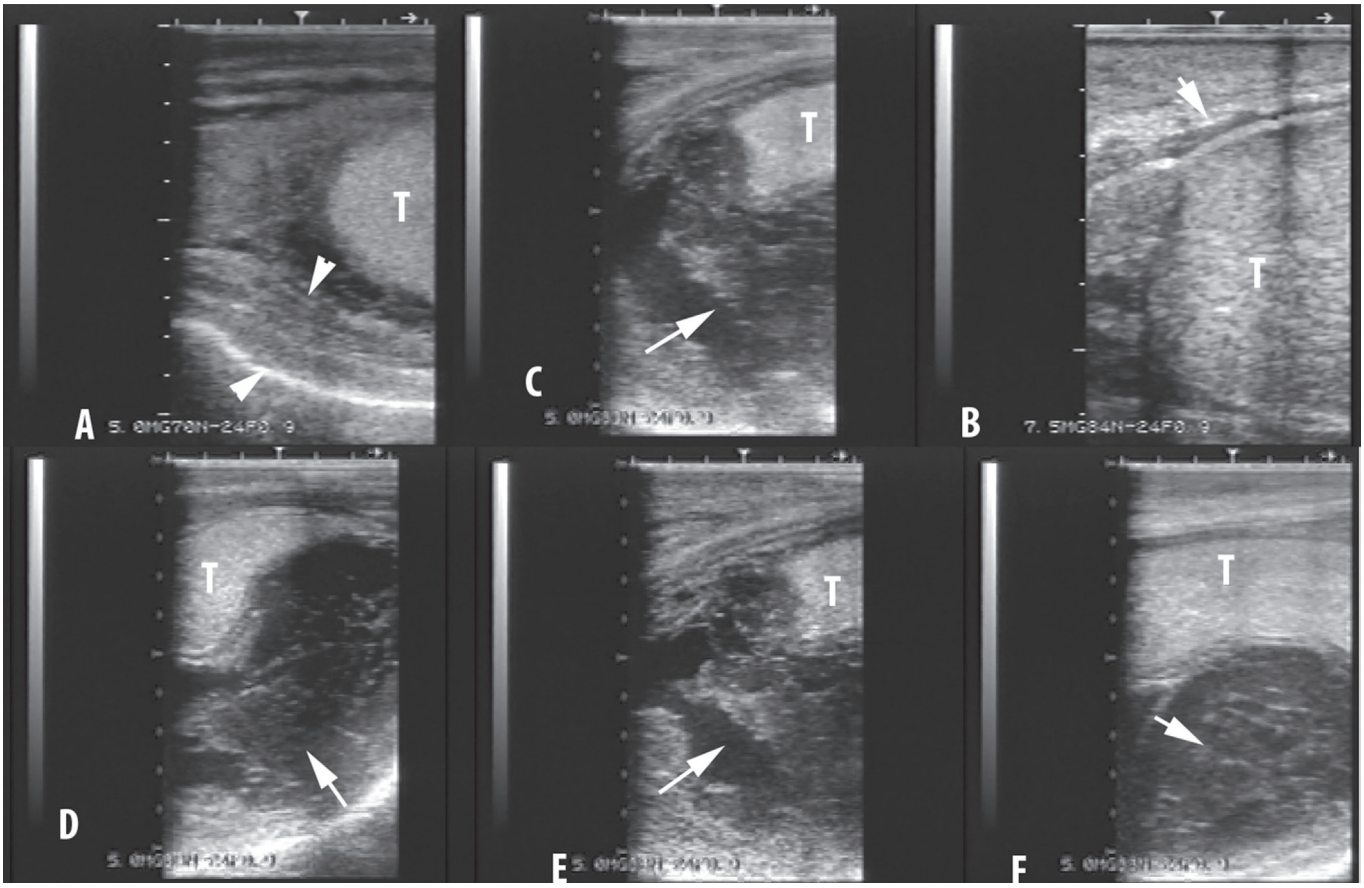

Figure 14: Ultrasonogram of a ram testis with severe orchitis and periorchitis. A- Arrows denote the thickened testicular envelops. B) Arrows denote the presence of pus in the vaginal tunic. C-F) arrow shows testicular abscess (T-testicular parenchyma)

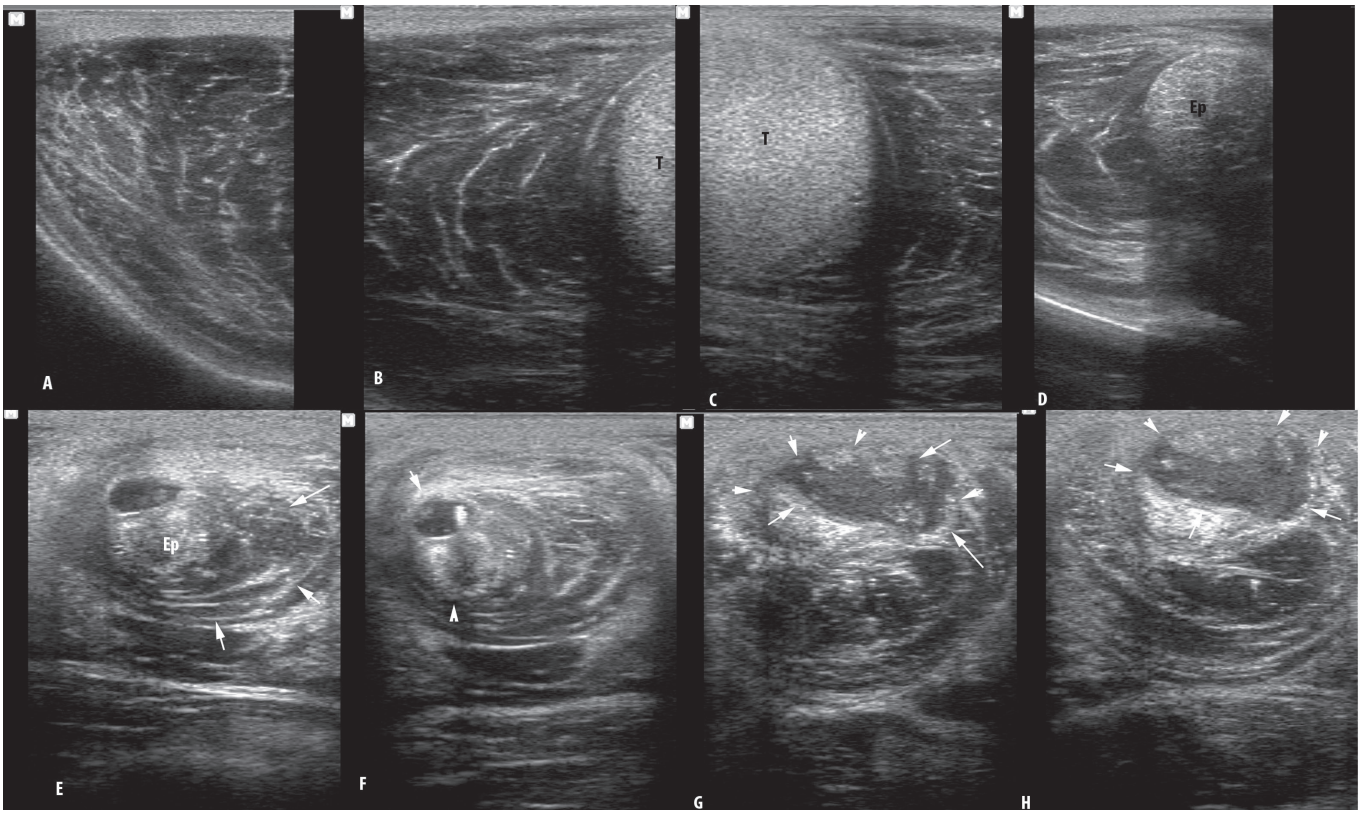

Figure 15: Periorchitis, orchitis and epididymitis in a ram. A-C) severe scrotal edema and edema of the vaginal tunic, T= testis, D) Edema surrounding the tail of the epididymis (Ep); E-F, epididymis (Ep) and epididymal abscess (arrows)

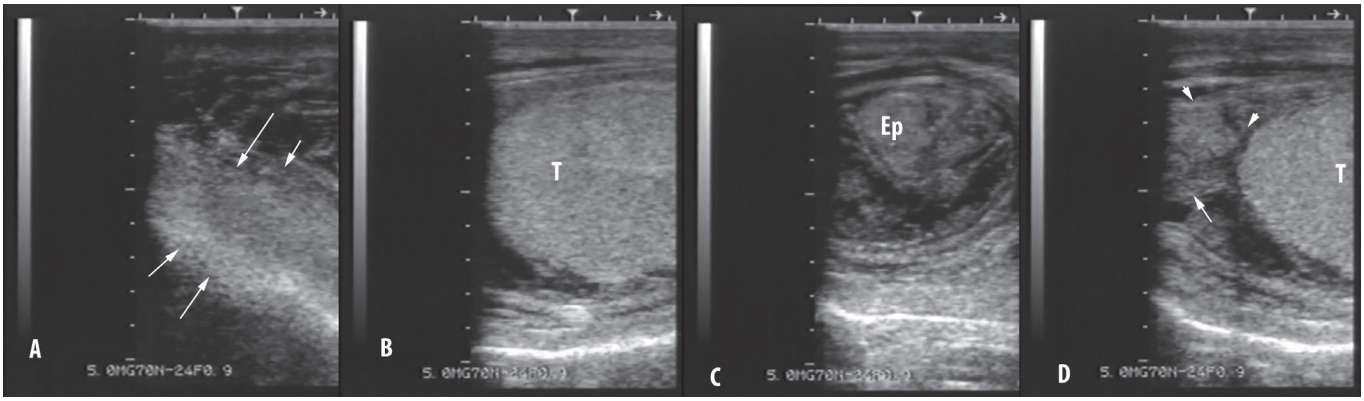

Figure 16: Periorchitis and orchitis in a ram. A-B) Thickened testicular envelops and hydrocele (arrows), T=testis; C-D, note the abnormal tissue, adhesions (arrows) and fibrin surrounding the testis and epididymis

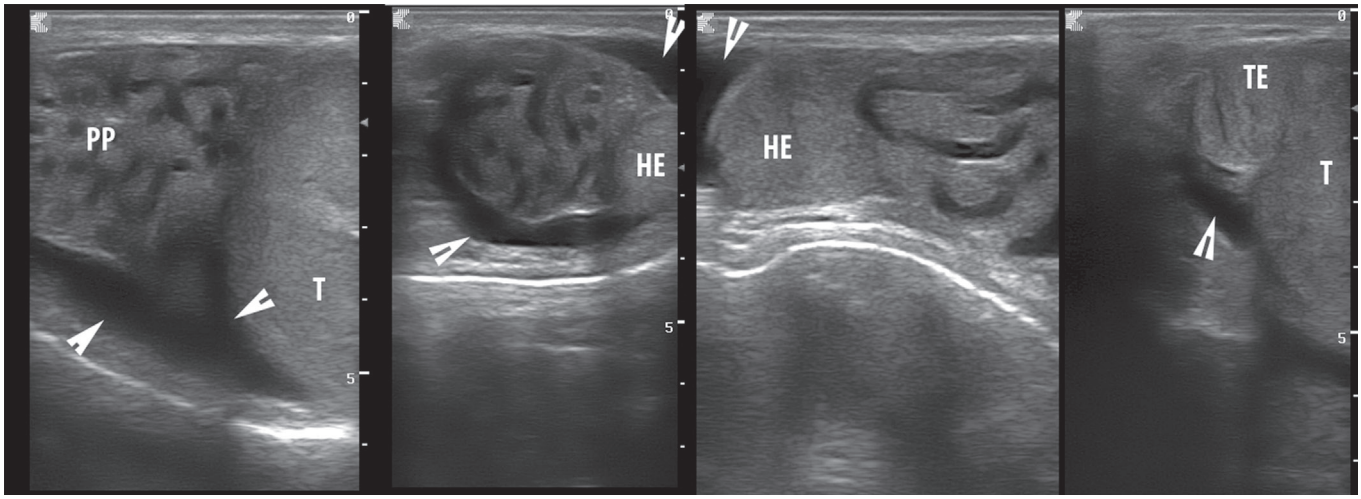

Figure 17: Hydrocele (arrows) in buck. Pp= pampiniform plexus, HE= head of the epididymis, TE= Tail of the epididymis, T= testis

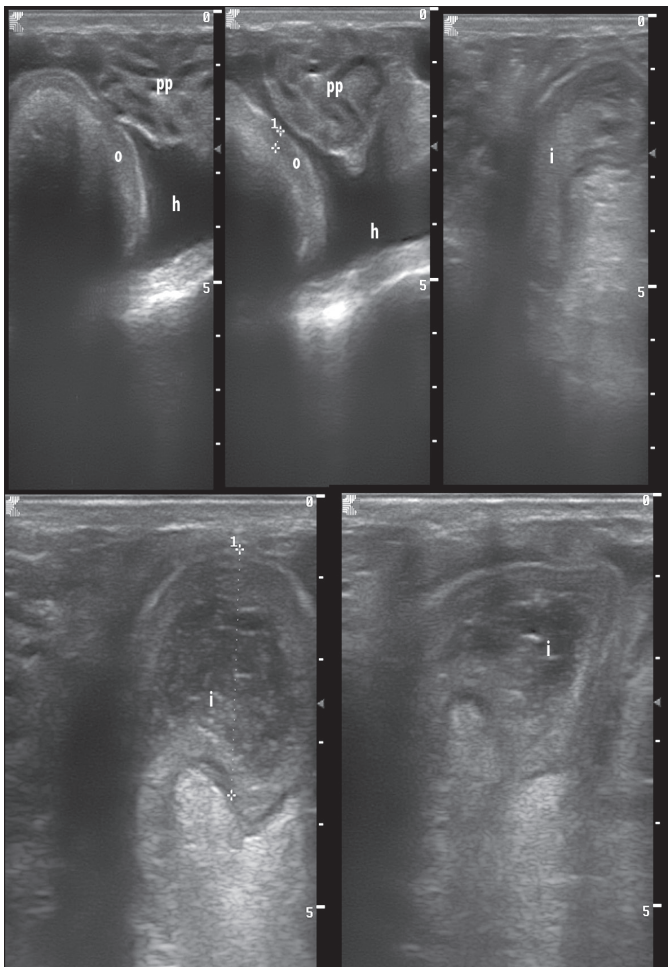

Figure 18: Inguinal hernia in a ram. Pp= pampiniform plexus; o= Omentum; h= hydrocele (peritoneal fluid); i= intestinal loop)

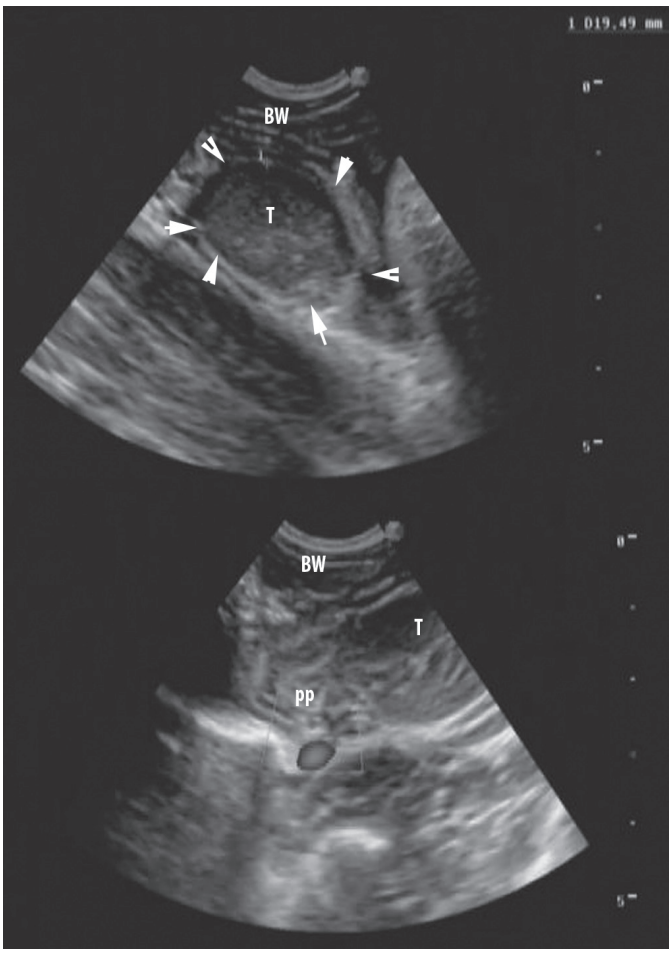

Figure 20: Ultrasonogram of intra-abdominal testis in a unilateral cryptorchid buck. BW= Body wall, T= testicle, pp=pampiniform plexus; abdominal testis is delineated by arrows

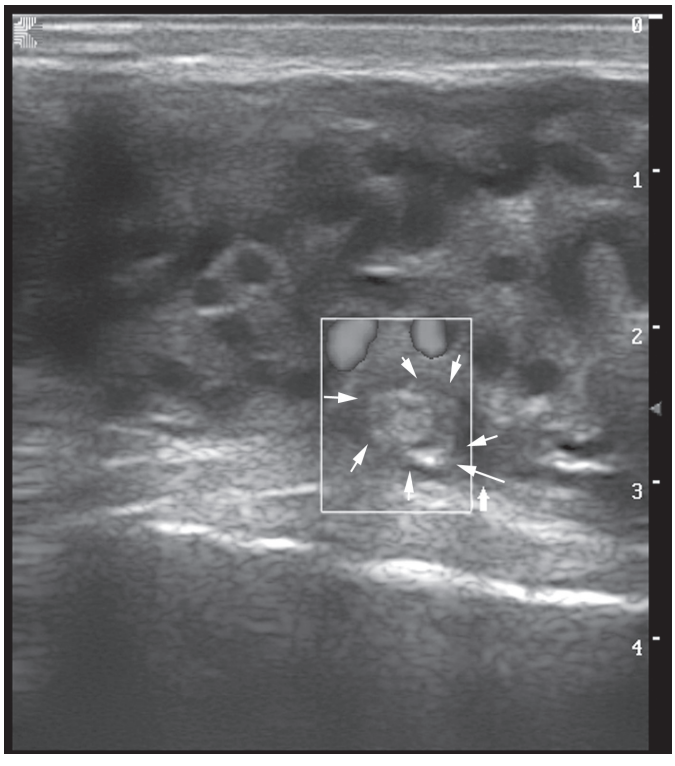

Figure 19: Abnormal spermatic cord presenting a nodule (arrows)

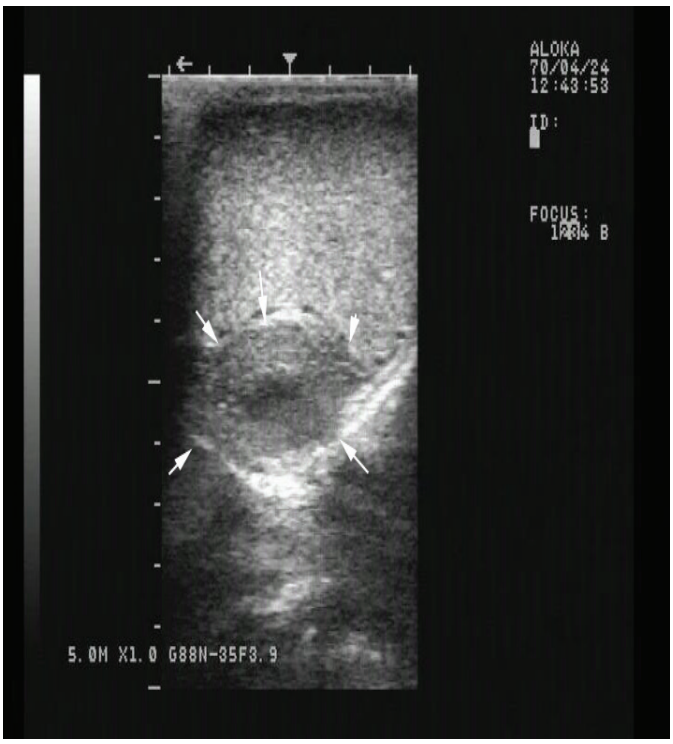

Figure 21: Ultrasonogram of a testicular abscess (arrows) in a ram

Abnormalities of the epididymis

The most common abnormalities of the epididymis are epididymitis and sperm granulomas. Enlargement and presence of echolucent lesions in the epididymis have been described in rams experimentally infected with *B. ovis* (Carvalho *et al.*, 2012).

Sperm granulomas/sparmastasis can be detected in the head or tail of the epididymis (Figures 26, 27). Early stages appear as anechoic well-circumscribed masses with distal enhancement. This appearance changes with time and becomes hyperechoic due to fibrosis of the lining tissue. A few echogenic spots may be visible within the lesion and correspond to calcification of inspissated

Intra-testicular sperm granulomas are microscopic and are not easily detected by ultrasonography. The only observation in these cases may be an increased heterogeneity of the parenchyma with numerous hyperechoic foci. Speckling (hyperechoic area with acoustic shadowing) of the testicular parenchyma can also be due to chronic testicular degeneration with calcification (Figure 24).

Testicular hemorrhage is not common and may result from severe trauma. The general echotexture of the testis is disturbed due to rupture of the albuginea (Figure 25).

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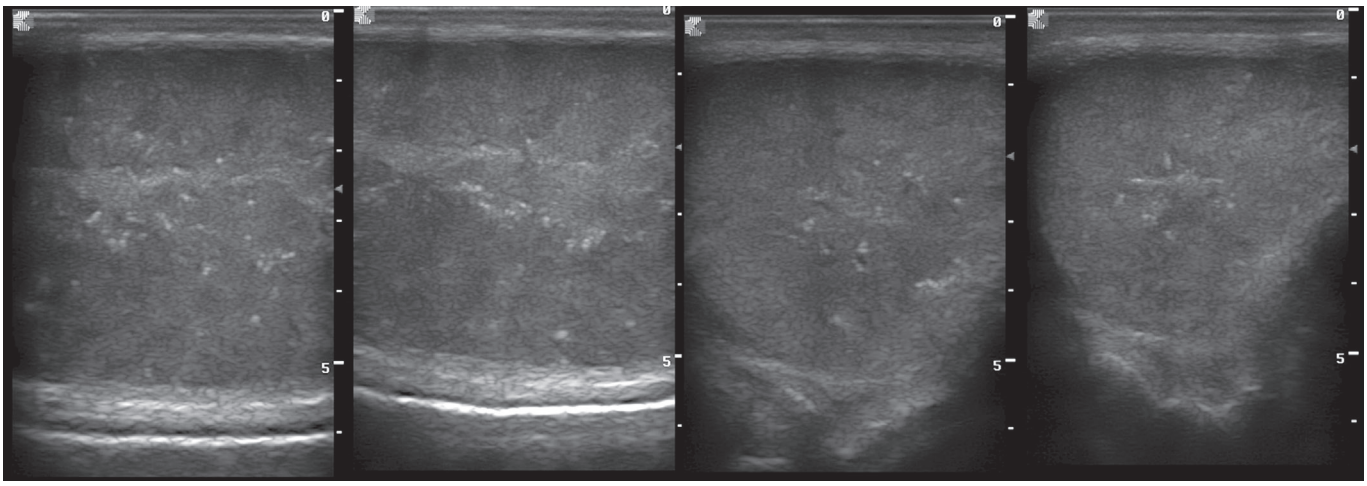

Figure 22: Ultrasonogram of the testis in an aged ram showing evidence of testicular degeneration and fibrosis (echogenic specks within the testicular parenchyma)

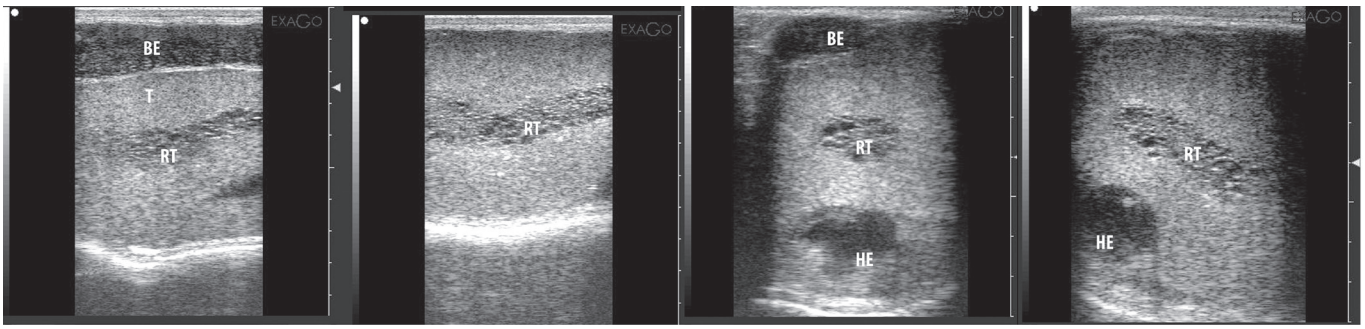

Figure 23: Ultrasonogram of a ram testis with dilated rete testis (cystic rete testis) due to spermastasis in the head of the epididymis. BE= Body of the epididymis, T= testis, RT= rete testis, HE= head of the epididymis

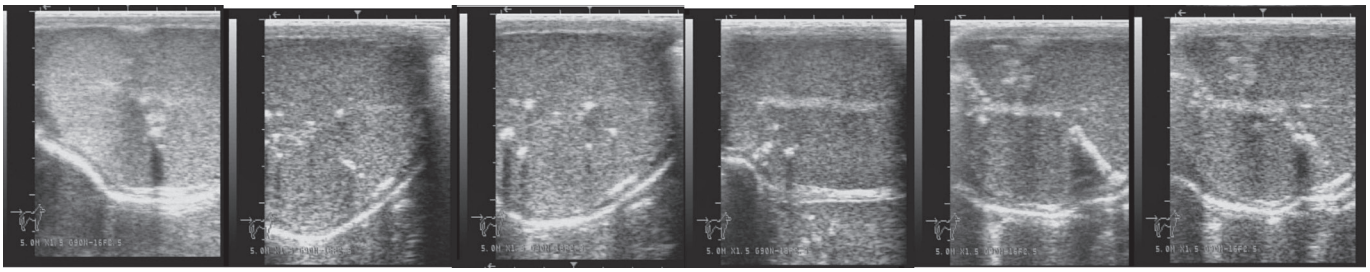

Figure 24: Ultrasonogram of ram testes showing various degrees of fibrosis with calcification

with or without a hyperechoic capsule. An enlargement of the mediastinum testis accompanies sperm granulomas of the head of the epididymis. Granulomas in the tail of the epididymis are usually anechoic or have mixed echogenicity with or without a hyperechoic capsule surrounding the lesions. Granulomas of the tail of the epididymis are not associated with an enlargement of the mediastinum testis (Karaca *et al.*, 1999).

In the acute phase, spermatic granulomas smaller than 1 cm can be detected by ultrasonography before they become palpable. Granulomas, localized in the head or tail of the epididymis or within the testis are associated with varying degrees of testicular degeneration (Karaca *et al.*, 1999).

Enlargement and decrease in the echogenicity of the mediastinum testis can be used as suggestive signs of granulomas of the head of the epididymis. This is clinically important because the pampiniform plexus frequently masks the head of the epididymis during ultrasonographic examination. Distension of the mediastinum testis can also be the result of segmental aplasia of the epididymis.(Karaca *et al.*, 1999) The absence of dilation and change in echogenicity of the mediastinum testis in the case of granulomas of the tail of the epididymis has been attributed to absorption of the accumulated semen by the epididymis.

Epididymitis and epididymal abscess may have variable appearance depending on the chronicity of the affection (Figure 28).

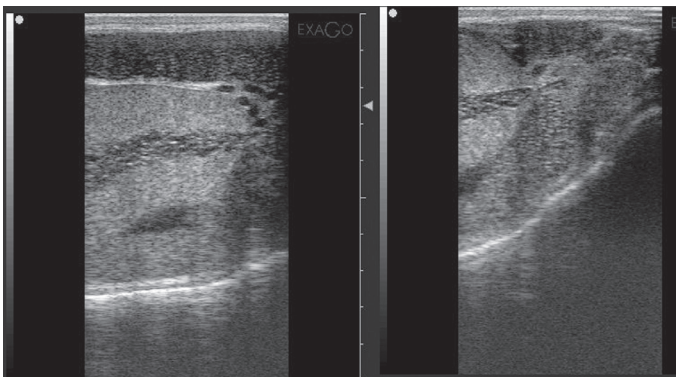

Figure 26: Sparmastasis in the body and head of the epididymis with cystic dilation of the rete testis in a ram.

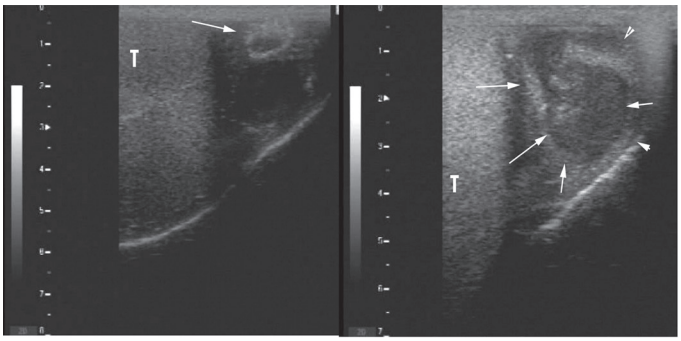

Figure 27: Sperm granuloma (arrows) in the tail of the epididymis of a buck

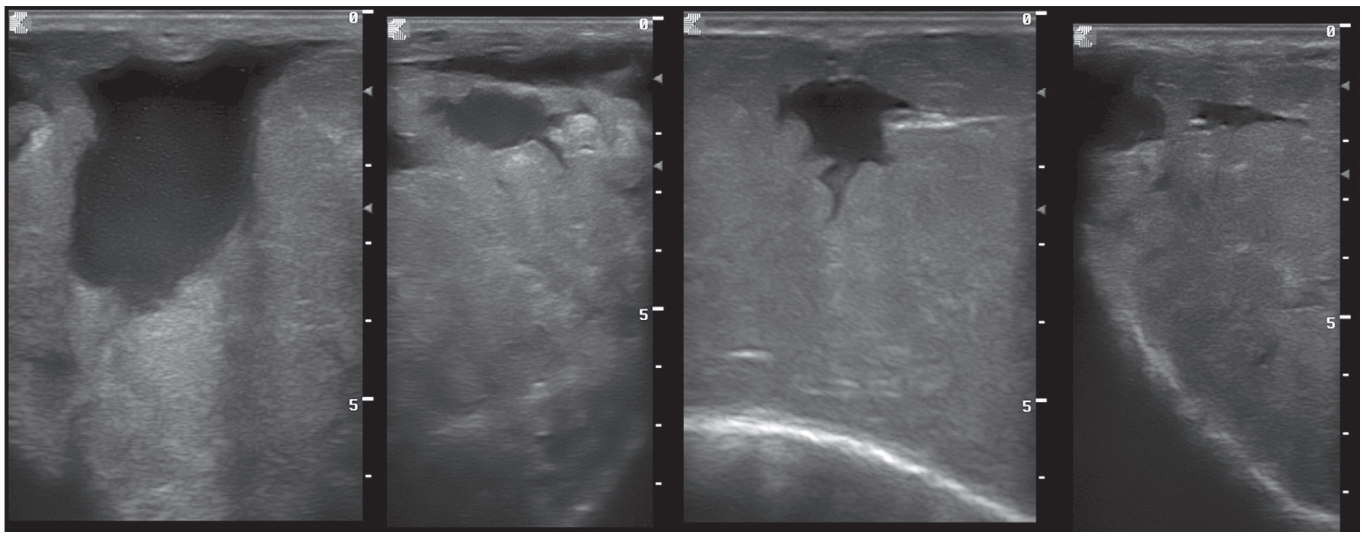

Figure 25: Ultrasonogram of a buck testis showing ruptured albuginea and hemorrhage.

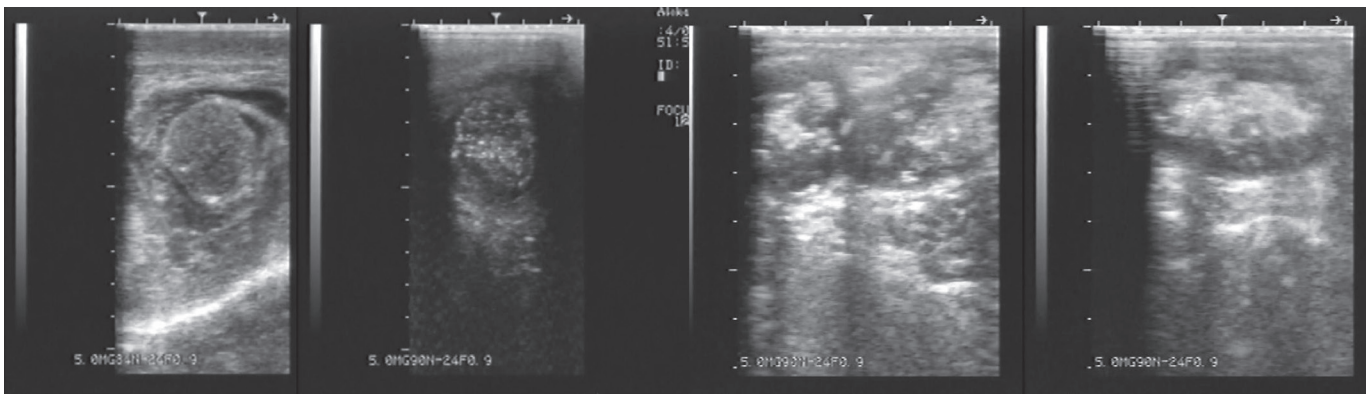

Figure 28: Epididymitis in a ram with epididymal abscess (bottom pictures).

Ultrasonography of internal genitalia

The bulbourethral glands, prostate, seminal vesicles and ampullae of the vas deferens can be imaged by transrectal ultrasnography but this examination is less common. Transrectal examination may be helpful in detecting some cases of seminal vesiculitis, spermastasis in the ampulae or locating retained testis (Camela *et al.*, 2014).

Transrectal ultrasonography is also helpful is some cases of suspected urolithiasis. Enlargement of the seminal vesicles has been reported in *Brucella ovis* infected rams (Carvalho *et al.*, 2012). A linear array transducer is mounted on a handle (Figure 29).

The rectal cavity is cleared of fecal content and a coupling gel is infused. The anatomy of the internal genitalia is described in details above. The bulbourethral glands are identified as round structure immediately adjacent to the anal sphincter (Figure 30). The pelvic urethra is identified on midline (Figure 31). The prostate is small in the ruminant and is present at the end of the pelvic urethra (Figure 32).

The vesicular glands (seminal vesicles) are multilobulated and may present some dilation in stimulated males (Figure 33). The ampullas of the ductus deferens are recognized by their thick muscular wall and lumen (Figure 34).

Figure 29: Transrectal ultrasonography technique in a ram: The linear array transducer is mounted on an extension rod (top). The rectal cavity is evacuated from feces and lubricated prior to introduction of the transducer (bottom)

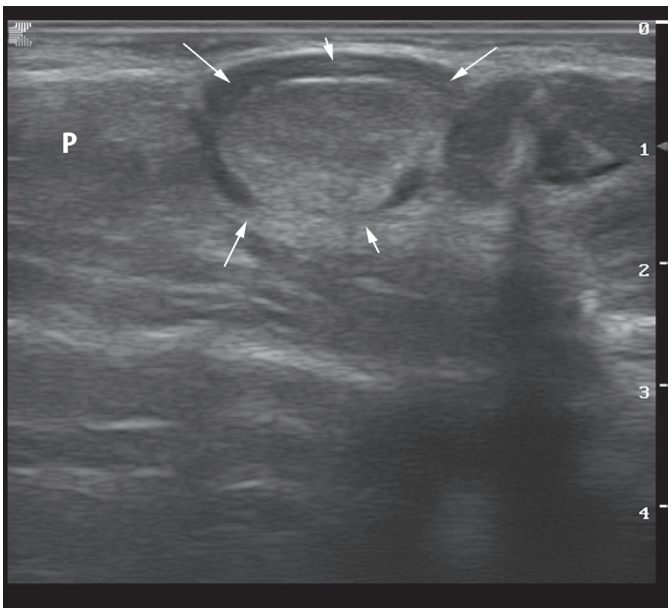

Figure 30: Transrectal ultrasonogram of the normal bulbourethral gland (arrows). P= pelvic portion of the urethra in a ram

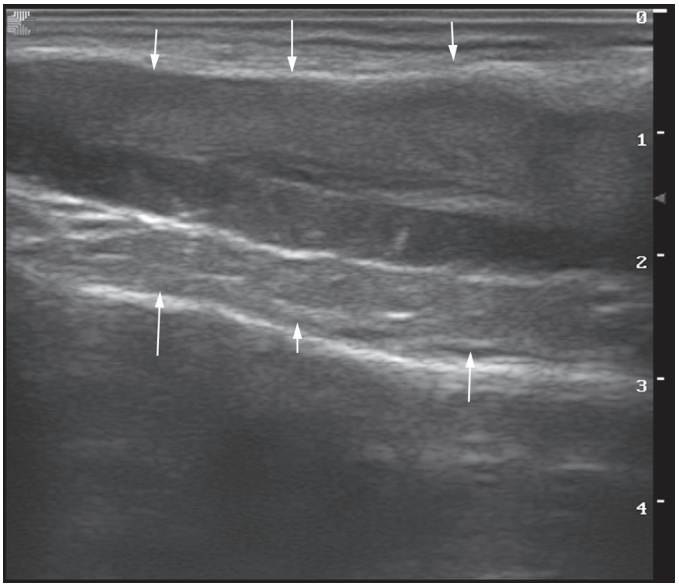

Figure 31: Transrectal ultrasonography of the normal pelvic urethra in a ram

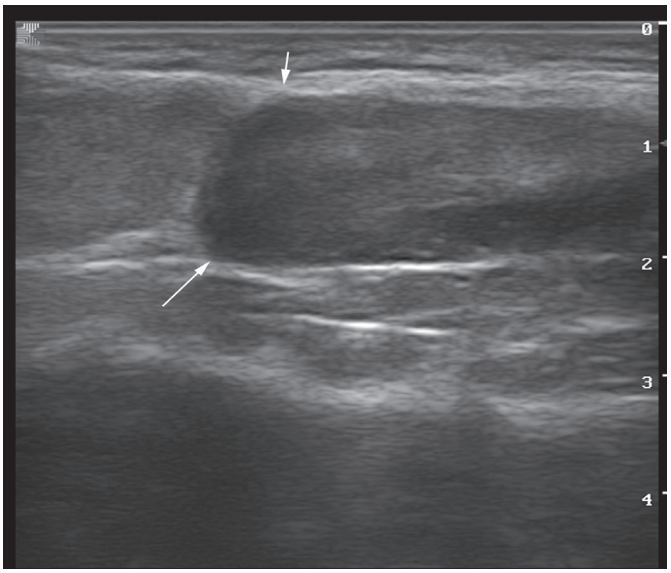

Figure 32: Transrectal ultrasonography of the normal prostate in a ram

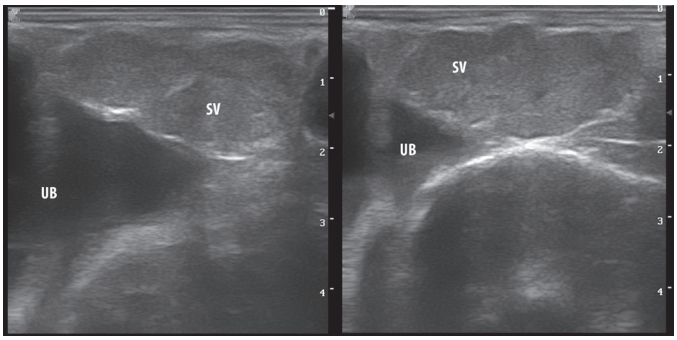

Figure 33: Transrectal ultrasonography of the normal seminal vesicle (note the lobulated aspect of the gland) in a ram. UB= urinary bladder, SV= seminal vesicle

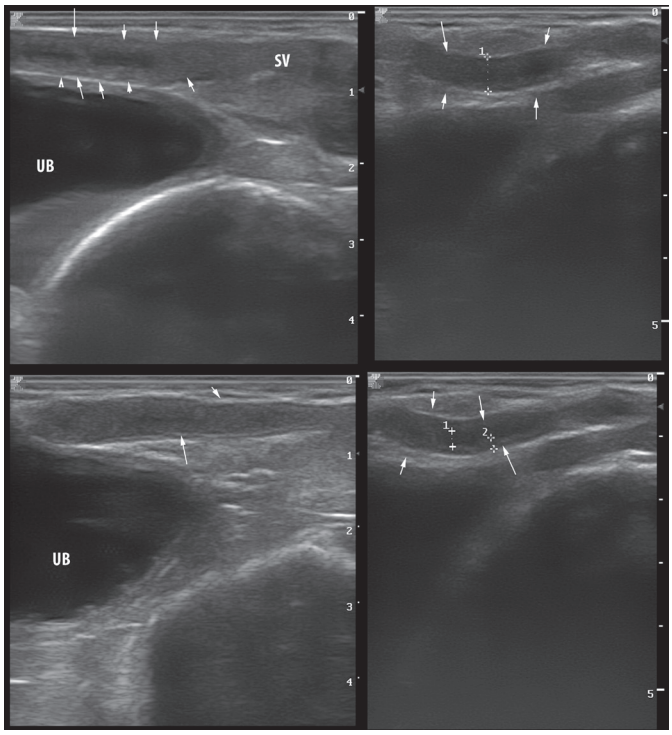

Figure 34: Transrectal ultrasonography of the normal ampulla of the vas deferens. Note the tick muscular wall and the presence of a clear lumen

CONCLUSION

The ultrasonographical examination of the reproductive tract is a potentially valuable tool for the diagnosis of reproductive pathologies in rams and bucks. It should always be preceded by a complete BSE. It may give valuable information in the diagnosis of fluid accumulation, sperm granuloma, epididymitis and subclinical orchitis.

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