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ULTRASONOGRAPHIC EVALUATION OF PROSTATE GLAND IN DOGS

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Thesis submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **"ULTRASONOGRAPHIC EVALUATION OF PROSTATE GLAND IN DOGS"** is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled **"ULTRASONOGRAPHIC EVALUATION OF PROSTATE GLAND IN DOGS"** is a record of research work done independently by **Dr. Divya R. Nair**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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Introduction

1. INTRODUCTION

Dogs are considered to be the first domesticated animal. They became man's best friend 14,000 years ago and, with the passage of time, the bond continues to grow stronger. Today, when automation and mechanization is the order of the day, the dog has carved a niche for itself in the hearts of mankind as a companion par excellence. Sharing our environment with dogs has a profound effect on the health of the humans concerned. There is a positive relationship between the presence of suitable pet animals and the sociability and health of elderly and mentally disturbed patients.

Among the developing nations, India has acquired a significant place in canine sport and keeping of companion animals. It is estimated that around 60 different breeds of dogs are currently present in our country. According to the Quinquennial livestock census- 2003 (AHD, 2004), the domestic dog population in Kerala is 11.31 lakhs. Apart from companionship, dog breeding is highly rewarding financially, which has led a lot of persons to take up dog breeding commercially. Routine reproductive evaluations of male dogs are often requested by breeders to confirm fertility prior to purchase or sale. The role of veterinarian is clear in providing the guidance required to promote responsible pet ownership.

The importance of male fertility in the dog breeding industry does not need to be stressed upon. Infertility is the stage where the dog is having less productive capacity and in most of the cases, it occurs as a result of some disease. The earlier the disease is diagnosed, the more are the chances of the dog regaining fertility.

Lack of breeding success is often multifactorial. Most of the infertility problems in male dogs were related to the pathology of the prostate gland. Conditions involving the prostate gland required a comprehensive breeding soundness evaluation including collection and evaluation of semen, digital palpation of prostate and potential ultrasonography of the prostate.

The prostate gland is the only accessory sex gland in the male dogs which is a musculo- glandular, bilobed and bilaterally symmetrical ovoid, with a median furrow encircling the neck of the urinary bladder. Not only does the prostate gland produce fluid, which transports and supports the sperm, it also produces many factors which influence the sperm fertility.

The normal size and shape of the canine prostate gland are reported to vary depending on age, breed and body weight. The normal size of the canine prostate gland has not been properly established and there is a paucity of data on normal and abnormal prostate parameters. Estimation of prostate size is important in diagnosis of prostatic diseases and in monitoring the response. There are several clinical methods to evaluate prostate size in the dog including rectal palpation, radiography, ultrasonography etc.

Ultrasonography provides a reproducible and accurate method of measuring prostate dimensions via transabdominal or transrectal routes. The ultrasonographic appearance of the prostate gland provides information on the shape, dimensions, lobular structure and echo texture of the gland parenchyma.

As there is paucity of information on prostatic biometry, prevalence of prostatic disorders as well as the relationship of breed, age and body weight with prostatic measurements, the work was undertaken with the following objectives:

1. To evaluate the prostate gland in adult male dogs and to record its biometry using ultrasonography.
2. To correlate various prostatic parameters with breed, age and body weight.
3. To ascertain the prevalence of prostatic disorders among adult dogs.

Review of Literature

2. REVIEW OF LITERATURE

Semen consists of spermatozoa and seminal plasma. The seminal plasma is derived from the secretions of testes, epididymis and accessory sex glands. Though earlier the accessory sex glands were thought to be 'accessory', their importance with respect spermatozoa fertility is well established now. Prostate gland is the only accessory sex gland in male dogs and it plays an important role in the reproductive performance of male dogs.

Memon (2007) observed that infertility among dogs resulted in substantial financial losses to the ever-expanding canine breeding and a complete breeding soundness evaluation was essential for assessment of infertile male dog. History including general health and reproductive performance followed by thorough physical examination were key initial steps in the assessment of an infertile dog. Most of the infertility problems in male dog were related to the pathology of the prostate. Conditions involving the prostate gland required a comprehensive breeding soundness evaluation including collection and evaluation of semen, digital palpation of prostate and potential ultrasonography of the prostate.

2.1. ANATOMY OF THE PROSTATE GLAND

Feeney *et al.* (1991) opined that the prostate gland, which surrounded the proximal end of the urethra, was immediately caudal to the neck of the bladder and positioned between the rectum and pelvic symphysis. The peritoneal coated, dorsal surface of the prostate was flattened and had a median sulcus.

The ducts of the prostate opened into the pelvic urethra near those of ductus deferens (Anderson and Anderson, 1994).

Feldman and Nelson (1996) stated that the prostate gland encompassed the neck of the urinary bladder, the proximal portion of the urethra and the terminal portion of the ductus deferens. A median septum divided the prostate into two equal sized, smooth, firm lobes which could easily be palpated per rectum.

Wallace (2001) and Budras *et al.* (2002) stated that the prostate had a body (external part) with two glandular lobes and a slight disseminate part (internal part), the glandular lobes of which were located in the wall of the urethra and surrounded by the urethralis muscle.

Smith (2008) found that the canine prostate gland was oval to spherical and had a dorsal and ventral sulcus and was encircled by a fibromuscular capsule. It lied in close apposition to the bladder cranially, rectum dorsally, pubic symphysis ventrally and abdominal wall laterally.

2.2. HISTOLOGY OF THE PROSTATE GLAND

Dellmann and Wrobel (1987) and Kustritz and Klausner (2000) stated that the right and left lobes of the prostate were further divided into lobules by trabeculae. Tubulo-alveolar glands were organized within the lobules and their secretions left the glands via small ducts, which emptied into the urethra.

The right and left lobes of the prostate were subdivided into lobules by finer septa that radiate outward to the capsule (Dyce *et al.*, 2002)

Samuelson (2007) stated that much of the glandular parenchyma of the prostate was located within the body of the prostate consisting of multiple compound tubulo-alveolar segments and empty their secretions directly into the urethra. The disseminate part had fewer tubulo- alveolar segments.

2.3. POSITION AND SIZE OF THE PROSTATE GLAND

Gordon (1961) reported that the position of the prostate was not affected by distention of the bladder or rectum or the postural factors. A relationship between the age of the dog and the position of the prostate was described. In castrated or cryptorchid dogs, the prostate were atypically pelvic in position. In animals which were prenatal, new born and less than two months old, the gland was located intra-abdominally where as in pups of 2 to 8 months old; the gland was pelvic in position. The author observed that in young pups where the urachus was still present, the prostate was abdominal in position. And after the rupture of the urachus, it became pelvic in position. After sexual maturity, the prostate increased in size and with increasing age, it changed in position from pelvic to abdominal and after the age of 10 years, it was intra abdominal. A constant relationship between weight of the prostate and the body weight of the animal was also reported.

According to Burk and Ackerman (1986), the prostate did not extend cranial to the brim of the pelvis, in normal conditions. But in some chondrodyplastic breeds, the prostate's perimeter extended cranial to the brim of the pelvis.

The prostate gland had undergone three distinct phases of activity during the life of the dog. In the young adult dog of 1 to 5 years of age, there was normal growth. In the middle age of 6 to 10 years, hyperplasia occurred and in old age greater than 11 years, there was senile atrophy (Allen *et al.*, 1991).

Basinger *et al.* (1993) noticed the prepubertal prostate around the pelvic urethra as a small nodular enlargement not more than 1 cm diameter in Beagle dogs. They observed that an immature prostate gland encircled the urethra which was small, and had faintly distinct lobes.

Krawiec and Heflin (1992) observed that the size of the prostate gland in healthy intact male dogs increased with the size and age of the dog.

The prostate was normally located near the cranial rim of the pelvis although cranial displacement into the abdomen occurred as the bladder distended with urine (Feldman and Nelson, 1996).

According to Ruel *et al.* (1998), prostatic measurements like length, width, height, weight and volume were positively correlated with age until 11 years after which senile involution of prostate occurred.

Prufer *et al.* (2000) reported that the prostate gland in young dog was an almond shaped gland while in old dogs it was oval or round.

Prior to two months of age the prostate was located within the abdominal cavity. After the breakdown of the urethral ligament until sexual maturity, the prostate lied in the pelvic canal. With increasing age, the prostate enlarged and moved over the pelvic brim into the abdomen (Henson, 2001).

Wallace (2001) found the prostate mostly in the retroperitoneal space and resided within the pelvic canal at the pelvic inlet. The normal gland was larger in older dogs and the Scottish terrier was known for having a larger than average prostate gland. If the gland was abnormally enlarged, it would often fall into the abdominal cavity.

According to Budras *et al.* (2002) and Dyce *et al.* (2002), the compact part of prostate varied greatly in size and this obviously affected its position and relations. At young age the prostate gland was located mostly in the pelvic cavity but as age advanced, it was intra abdominal.

Vestergen and Onclin (2002) stated that there were three periods in the development of the prostate gland. The first one corresponded to the period of embryogenesis and first post natal development and ends at 2 to 3 years. The second one was the androgen dependent exponential hypertrophic development up to 12 to 15 years. The last phase was the senile involution phase where the androgens decreased.

Menon (2004) found that there was an increase in the prostatic weight associated with increasing age.

In prostatic epithelial cells, testosterone produced by the Leydig cells of testes was converted by 5-α reductase to 5-α dihydro testosterone which regulated prostatic development and function (Memon, 2007).

Romagnoli (2007) observed that the normal prostate gland of intact male dogs increased in weight due to normal growth and glandular hyperplasia for the first five years with a peak of four years old. Like in human beings, prostate of a mature dog was chronically dependent upon a continuous supply of androgen to maintain its appropriate cell content and functional activity.

Smith (2008) reported that the prostate gland assumed its mature size as puberty approached and blood testosterone increased. With age and continued exposure of testosterone, the gland began to undergo hyperplasia.

Gadelha *et al.* (2009) found that the prostate growth was higher until six years old and after that the growth was lower since gland alterations did not occur. The prostatic growth was a physiological event in dog's life without cell alterations but when benign prostatic hyperplasia occurred the growth was associated with cell alterations.

2.4. SECRETIONS AND FUNCTIONS OF THE PROSTATE GLAND

Basinger *et al.* (1993) found that maintenance of normal quantity and quality of prostatic secretion required adequate stimulation by androgenic hormones and androgen dependent level of arginine esterase reflected the hormonal status of the dog. Arginine esterase was a prostate derived enzyme found in high concentration (10mg/mL) in seminal plasma. The authors found that, acid phosphatase present in small quantities in the canine prostatic secretions, was a common marker of human prostatic function. They further observed that the volume of canine prostatic fluid varied from 2 to 30 mL during a period of 3 to 35 minutes.

Smith (1999) stated that the secretions of the prostate gland contributed to the seminal fluid. Because the prostatic portion of the male urethra passed through the prostate gland, the ducts of the prostate opened directly into the lumen of the prostatic urethra.

Kustritz and Klausner (2000) noticed that more than 90 per cent of the total fluid volume of semen was attributed to prostatic secretion, making semen as an ideal sample for cytology and microbial culture of prostatic secretion. The normal prostatic fluid was clear and relatively acellular.

The prostate gland contributed a large volume of fluid to the volume of ejaculate and was mostly delivered as part of the post semen fraction of the ejaculate. About 97 per cent of the volume of an ejaculate was contributed by the prostate gland (Pineda, 2003).

Adams (2004) and Dallas (2006) observed that the prostate produced an alkaline fluid which neutralized urethral acidity, aided in the activation of sperm, formed the bulk of the seminal fluid and accounted for the characteristic odour of semen.

2.5. INFLUENCE OF CASTRATION ON THE SIZE OF PROSTATE

Feeney *et al.* (1987) and Basinger *et al.* (1993) found that after castration the involuted prostate was small and ultrasonographically hypo echoic and the lobes were less distinct.

According to Smith (1999), castration of a dog of any age will cause a marked reduction in the size of the prostate gland by removing the influence of testosterone. Castrations lead to decreased prostatic volume, atrophy of the glandular and stromal elements and decreased ability to take up and metabolise androgens (Kustritz and Klausner, 2000).

Lattimer (2002) reported that very small normal prostate glands in neutered dogs could not be observed ultrasonographically.

Pineda (2003) observed that the effect of castration on prostate gland varied with the age and stage of development at which orchiectomy was performed. Prepubertal castration prevented normal development of accessory sex organs where as post pubertal castration lead to atrophy. He found that the prostate of males castrated as adults might retain their precastration size because the stroma was maintained while function was severely impaired.

Al- Omari *et al.* (2005) evaluated the effect of androgen ablation on dog prostate gland structure and the proliferation capacity of the prostatic cells. They found that castration before two weeks induced progressive changes in the prostate gland characterized by a marked shrinkage of prostatic acini and the fibromuscular tissue continued to increase in its density and appeared as a dense compact structure. The results indicated that androgen was required for the survival of epithelial cells and to maintain growth-quiescent fibromuscular cells, while basal cell proliferation was androgen independent.

In neutered males, the prostate was just a pod or "flair", bulging out of the width of the urethra in ultrasonography. The neutered male prostatic pod appeared isoechoc with the urethra and was much more hypo echoic than the intact male prostate (Gradil *et al.,* 2006; Davidson and Baker, 2009).

2.6. DIGITAL PALPATION OF THE PROSTATE

Allen *et al.* (1991) palpated the prostate gland per rectum using middle or index finger suitably protected with a glove. It was suggested that the ease of palpation depended on the length of finger, the size of the dog and the condition of the prostate.

The proximity of the rectum and the prostate gland together with the thinness of the rectal wall facilitated digital palpation of the prostate gland per rectum. This procedure should be part of the physical examination of intact male dogs regardless of age (Smith, 1999).

According to Kustritz and Klausner (2000), in large dogs elevating the fore quarters facilitated per-rectal examination of the prostate.

Wallace (2001) and Davidson (2003) found that the normal prostate was smooth, moderately firm, symmetric, non- painful and freely movable. The median groove of prostate was easily palpated.

Paclikova *et al.* (2006) and Memon (2007) observed that in rectal palpation on the medium sized dog, the prostate had the size of a walnut with smooth surface and solid consistency.

Transrectal digital palpation was the best method for physical examination of the prostate. The prostate was reached when one hand was used to push through the ventral abdomen, the neck of the bladder and prostate into the pelvic canal. Simultaneously the index finger of the other hand was used to perform the digital examination of the caudal aspect of the prostate gland (Smith, 2008).

Gadelha *et al.* (2009) carried out rectal palpation in 36 adult intact dogs of three age groups and evaluated the localization, size, consistency, symmetry and mobility. The pelvic location and smaller size of the gland were mainly observed in younger dogs of 1 to 3 years old and the abdominal localization was observed in 50 per cent of the animals older than 7 years. Their study indicated that palpation per- rectum allowed initial information about prostate condition and it was a valuable method to verify glandular alterations. Location and size indicated that as the dog became older, the prostate increased and moved from pelvic to abdominal cavity in its location.

2.7. ULTRASONOGRAPHY OF THE PROSTATE

Ultrasound is characterized by sound waves with a frequency higher than the upper range of human hearing and sound frequencies in the range of 2 to 10 MHz are commonly employed in diagnostic examinations. Real time ultrasound systems emit high frequency sound waves from a hand held transducer. An electric current when applied to the piezoelectric crystals in a transducer produces vibration of the crystals which results in acoustic pressure waves transmitted to the tissue. The sound waves are directed through the tissue by moving transducer or varying the angle of the transducer. Tissues have either propagate or to reflect the sound wave to varying degrees. The proportion of the sound waves that is reflected or echoed is received by the same piezoelectric crystals in the transducer. These are then converted to electrical impulses and displayed on the ultrasound screen as a series of grey dots.

Feeney *et al.* (1987) suggested that prostatic size and consistency could be better evaluated with ultrasonography than with radiography. Radiographic assessments overestimated the size of the prostate due to the silhouette sign with the colon, abdominal wall and other structures in the peri-prostatic area. In normal dogs the prostatic parenchyma appeared echogenic and the parenchymal pattern had a fine texture in young dogs while old dogs showed a medium to coarse texture.

Juniewicz *et al.* (1989a) found that sonographically prostates were well differentiated, being isoechoic to hypo echoic in appearance. Prostates were generally homogeneous in echogenecity.

Basinger *et al.* (1993) evaluated the prostate gland for changes in size, shape, margination, symmetry, echogenicity and internal cavitary areas. The immature prostate gland had a hyper echoic appearance and the fully developed gland in an intact dog had a uniform homogeneous pattern throughout both lobes. The normal prostatic parenchyma was described as normal, focally involved or diffusely affected. The authors demonstrated that the prostatic echogenecity was slightly hyperechoic relative to the spleenic parenchyma and the relative quality was influenced by the transducer and other factors such as sexual maturity of the dog. It was recommended to use a 10 or 7.5 MHz transducer or higher to evaluate prostate gland ultrasonographically as it provided sufficient resolution of the prostatic parenchyma. A five or 3.5 MHz transducer provided useful information about the prostatic size, location and gross architexture but was not adequate to provide internal details needed for a diagnosis.

Mattoon and Nyland (1995) suggested that the ultrasonographic appearance of normal prostate varied with age, intact or neutered status, type and quality of the ultrasound equipment and machine settings. The normal prostate in a young to middle aged intact dog had a fairly homogeneous parenchymal pattern with a medium to fine texture. The echogenicity was variable from hyperechoic to hypoechoic although moderate echogencity was most common.

It was easiest to identify the prostate by locating the urinary bladder in a transverse plane and then moving the transducer caudally following the bladder until the bladder narrows at the neck. Prostate was uniformly hetero-echoic round or bilobed structure surrounding the bladder neck or urethra. The median raphae and the capsule were not obvious and the gland appeared more round than bilobed. As the bladder distended, the prostate was pulled anteriorly out of the pelvic canal and that permitted easy prostatic evaluation (Burk and Ackerman, 1996).

Johnston *et al.* (2001) noticed that it was easy to obtain a prostatic image with the dog in dorsal or lateral recumbency often with out the need of sedation.

Lattimer (2002) observed that the normal prostate was uniformly echogenic with an echogenecity very similar to the surrounding fat. The bilobed shape of the prostate gland was recognized on the transverse image plane.

2.7.1. Transrectal ultrasonography

Juniewicz *et al.* (1989b) found that transrectal ultrasound was an accurate method of estimating canine prostatic weight. Although direct caliper measurement was slightly more accurate than transrectal ultrasound, caliper measurement was invasive and the number of measurements that could be conducted over the course of a study was limited.

Large foot printed linear transducers were not adequate to access the prostate gland because of the pelvic location of the gland and inability to maneuver the ultrasound beam within the pelvic canal with out interference by the bony pelvic canal (Basinger *et al.*, 1993).

Mattoon and Nyland (1995) opined that the advantage of transrectal ultrasound scanning in prostate scanning was the enhanced image quality because of the overlying anatomic structures and the ability to optimize the short focal zone. Disadvantages in small animal practice were inconvenience, discomfort of the patient and necessity of sedation and anaesthesia. The scanning was performed with the patient in sternal, lateral or dorsal recumbency. They authors also opined that the transducer must be well lubricated and advocated the use of a probe sheath.

Green and Homco (1996) noticed that the 7.5 and 5 MHz linear array transducers provided the best image resolution for transrectal ultrasonography of the prostate gland. The patients were positioned in lateral or sternal recumbency or in standing position. A full urinary bladder was not necessary for transrectal scanning. The probe over the condom was filled with warm water or ultrasound gel and tape or an elastic band was used to secure the end of the cover to the probe. Ultrasound gel was placed on the outside for lubrication and coupling and the transducer was inserted slowly in to the rectum to the level of the neck of the urinary bladder. The transducer was then withdrawn, enabling the imaging of the entire length of the prostate gland. With the linear array single plane transducers typically used in veterinary medicine, sagittal views of each lobe of prostate could be obtained by slowly rotating the transducer from side to side.

Transrectal ultrasonography caused discomfort when the probe was introduced into the rectum especially for dogs with prostatic enlargement. The dog needed sedation or anaesthesia to undergo transrectal ultrasonography (Kamolpatana *et al.*, 2000).

Debiak and Balicki (2009) used transrectal ultrasound effectively for the detailed analysis of the caudo-dorsal prostate image and obtained good quality precision of the details of the structure of the capsule and subcapsule region in the cranio- dorsal part of the prostate with the transrectal ultrasound in all animals with a normal gland. But in dogs over 40 Kg, the images were not of satisfactory quality due to size.

2.7.2. Transabdominal ultrasonography

The ultrasound appearance of the canine prostate with histologic correlation had been reported by Cooney *et al.* (1992). In the study, prostate glands were harvested and studied in a water bath. On transverse ultrasonography, the body was bilobed. The urethra and peri-urethral tissue appeared hyper echoic in most cranial and most caudal sections of the gland. In transverse section, sexually mature prostatic parenchyma had an echogenic butterfly shaped appearance extending laterally into both lobes corresponding to collageneous fibres surrounding the ductal system. Dorsal and ventral to this were roughly triangular hypoechoic regions corresponding to glandular tissue. Glandular tissue was also noticed in the periphery of the prostate, creating a thin hypo echoic rim around the circumference of the prostate. Glandular tissue was noted to be less apparent at the cranial most extent of the prostate. On sagittal section, there was an oval central area of hyperechogenicity surrounded by hypoechoic tissue corresponding to collageneous and glandular tissue respectively. Sexually immature dogs showed diffusely hyper echoic prostate glands reflecting lack of glandular development and a preponderance of collagen. In both sagittal and transverse scans, the gland had a definite characteristic echogenic pattern which depended upon the histologic constituents of the particular area of the gland. Although transverse sections indicated that the urethra passed through the prostate gland from the gland's ventral surface obliquely to the gland's dorsal surface, sagittal scanning readily revealed that the prostatic urethra ran in a horizontal fashion through the gland.

Basinger *et al.* (1993) observed that as the caudal border of the prostate gland might be obscured by overlying pelvic bone and penis on the abdominal midline, oblique or angled planes were often necessary to image the gland. If the caudal border was still difficult to see, the gland could be pushed cranially by an assistant with rectal manipulation. They recommended sagittal, dorsal and transverse planes as the individual sections of the gland were identified by sweeping from one side of the gland to the opposite side.

Green and Homco (1996) and Kamolpatana *et al.* (2000) opined that transabdominal approach was most often used in small animal ultrasonography. Scanning was mostly accomplished by using a 5 or 7.5 MHz transducer and a 3.5 MHz transducer was used for very large dogs. The former found the capsule of the prostate gland as a uniform, slightly hyperechoic thickening all around the periphery of the prostate gland but difficult to detect with transabdominal imaging in most of the animals. They observed a hyperechoic central area with transverse imaging called hilar echo and represented the prostatic urethra and the periurethral ducts. The hilar echo was surrounded by a hypoechoic zone caused by the smooth muscles.

Partington (2002) observed that for abdominal ultrasound in smaller dogs of 15 kg or less, a 7.5MHz transducer was ideal. For middle size to large breed dogs, a 5 MHz transducer worked well. He ranked small animal abdominal organs from least echogenic to most echogenic as renal medulla, liver, renal cortex, spleen, prostate and renal sinus fat.

Romagnoli (2007) found that the canine prostate was best evaluated in the sagittal and transverse planes using 5.0 or preferably 7.5 MHz scanners. The author advised to administer an enema prior to scanning to eliminate colonic contents which might mimic peripheral prostatic disease.

The normal intact prostate gland located in the pelvic canal had fairly uniform echogenecity, a smooth stippled texture and echogenecity similar to that of spleen. Its shape was bilobed in the transverse plane and oval in the longitudinal plane. A hyperechoic "butterfly "pattern was noted in the transverse image that corresponded to the distribution of ductal tissue which had more echogenic connective tissue than the hypoechoic glandular tissue. The normal prostatic capsule was difficult to detect (Davidson and Baker, 2009).

Gadelha *et al.* (2009) efficiently determined the shape, size, contour and integrity of the prostate gland of 36 intact male dogs ultrasonographically. The canine prostate was found to be round with a regular surface and presented homogenate parenchyma texture characterized by hyperechoic areas within lower echogenecity areas in all animals between one to six years old. Dimensions varied according to age, being small in young animals and large in old ones. There was a positive correlation between prostatic dimensions and body weight and age of the animal. The study indicated that ultrasonographic examination was essential to characterize the morphology of canine prostate and detect probable cavity lesions.

2.7.3. Ultrasonographic measurement of the prostate

Several authors have developed various formulae for calculation of prostatic volume and weight after detailed ultrasonographic measurements of prostate.

Juniewicz *et al.* (1989b) had done transrectal ultrasonography of prostate gland in 20 male dogs. Sonograms were obtained in both the transverse and sagittal planes with the dogs in dorsal recumbency. The width of the prostate was determined in transverse plane and the length and depth were determined in sagittal plane. Prostatic volume was calculated using the equation:

$$\text{Prostatic volume (cm}^3\text{)} = \text{length (cm)} \times \text{width (cm)} \times \text{depth (cm)}$$

Prostatic weight was calculated using the formula:

$$\text{Prostatic weight (g)} = \text{prostatic volume (cm}^3\text{)} \times 0.602 \times 1.16$$

The weight obtained by the formula was similar to the true gravimetric weight.

Ruel *et al.* (1998) performed transabdominal ultrasonography of 100 sexually mature male intact dogs. The mean age of dogs was 5.1 ± 3.4 years and the mean body weight was 18 ± 11.8 Kg. Length and height were measured on the sagittal images and the height and width on transverse images. Prostatic volume was estimated using the formula for an ellipsoid volume:

Volume = length × width × height × 0.523.

On sagittal images of the prostate, the mean length was 3.4 ± 1.1cm and the mean height was 2.8 ± 0.8cm. On transverse images, the mean width was 3.3 ± 0.9cm and the mean height was 2.6 ± 0.7cm. The mean calculated volume was 18.9 ± 15.5cm^3. They noticed a significant positive correlation between all prostatic measurements and the body parameters like body height and weight. Correlation coefficients were ranged from 0.35 to 0.68. A weak positive correlation ($p<0.05$) was found between all prostatic parameters and the age of the dogs.

Suzuki *et al.* (1998) opined that transrectal ultrasonography was the most prevalent method to monitor prostatic size and volume. They examined the prostate of twenty adult male Beagle dogs by transrectal ultrasonography. The length and height of the prostate gland were measured in the sagittal image and width was measured in transaxial image. The average length, width and height were 5.97cm, 4.4cm and 3.1cm respectively. The prostatic cubic volume was calculated from the data using the formula (length × width × height). Gravimetric prostatic volume was calculated by using the formula:

Gravimetric prostatic volume (g) = 0.642 × prostatic cubic volume (cm^3) + 1.84

They had found that gravimetric prostatic volume was highly correlated with prostatic cubic volume.

Atalan *et al.* (1999a) examined 34 male dogs with an average body weight of 32.4 kg and of average age 8.1 years. The Transabdominal ultrasonographic imaging was done through the caudo ventral abdominal skin in dorsal recumbency. From the image, the length and depth were measured. The measurements varied from 3.5 to 8.3cm (5.4±1.30 mean) for length and from 2.4 to 7cm (4.3 ± 1.11 mean) for depth. A survey abdominal radiograph was made in dog in right lateral recumbency. Radiographic prostate length varied from 2.8 to 8.6 cm and depth from 2.5 to 7.1 cm. There was no difference between prostate length measured by radiographic and ultrasonographic methods. But there was a significant difference between measurements of prostatic depth by the two methods. The study indicated that radiographic prostatic depth was an unreliable estimate of prostatic size. Also radiographic methods were expensive and caused exposure hazards to both animal and examiner. The estimation of canine prostate gland size provided important information in the clinical evaluation of benign prostatic disease and in monitoring the response.

In a recent study by Atalan *et al.* (1999b), transabdominal ultrasonography of 154 male dogs of average age 4.3 years and average body weight 17.8 kg was done. There was no significant difference between prostatic depth on longitudinal (DL) and transverse sections. They calculated the prostatic volume and weight as 12.3 cm^3 and 11.2g respectively. The relationship between estimated prostatic volume, body weight and age was found to be:

Prostatic volume (cm^3) = 8.48 + (0.238 × Body weight (kg))

The equation for prostatic weight was formulated as:

Prostatic weight (g) = 6.01+ (0.373 × body weight in kilograms)

Statistically significant correlations were obtained between all the prostatic measurements. The body weight was a better predictor than age of both prostatic volume and prostatic weight.

Atalan *et al.* (1999c) calculated prostatic volume and weight in 77 male canine cadavers with the aid of computer programmes using actual linear dimensions of the prostate and those measured ultrasonographically. Their study demonstrated that the volume and weight were related to body weight and age in entire dogs but not in neutered dogs. Five and 7.5 MHz transducers were used and the following dimensions were measured. In longitudinal section, the maximal length (L) from cranial to the caudal pole of the prostate and maximal depth (DL) from the dorsal to the ventral part of the prostate were measured and in transverse section maximum width (W) and maximum depth (DT) were measured. The mean age and body weight of dogs were 27kg and 8.1years respectively. The median values for prostatic length, prostatic depth in longitudinal and transverse sections and prostatic width were 3.6 cm, 2.8 cm, 2.8 cm and 3.4 cm respectively. The authors derived formulae to estimate prostatic weight and volume from linear prostatic dimensions by comparing prostate volume and weight measurements with the actual linear dimensions of the prostate and those measured in vivo and in vitro. The derived formulae were:

a) For physical measurements

$$\text{Prostatic volume} = 0.625 \times (L \times W \times D) - 0.54$$

$$\text{Prostatic weight} = 0.628 \times (L \times W \times D) - 0.216$$

b) For ultrasonographic measurements

$$\text{Prostatic volume} = 0.487 \times L \times W \times (DL + DT) / 2 + 6.38$$

$$\text{Prostatic weight} = 0.508 \times L \times W \times (DL + DT) / 2 + 3.21$$

Highly significant correlations were obtained between actual and ultrasonographic prostatic measurements. Highly significant correlation was present between prostatic volume and prostatic weight in entire dogs ($P<0.001$). Significant correlations were obtained between prostatic weight and age, prostatic volume and age, body weight and prostate weight, and body weight and prostatic volume. No significant correlation was present in neutered dogs. The study indicated that prostatic width and length were the best predictors of prostatic volume and weight.

Kamolpatana *et al.* (2000) examined the dogs less than five years of age and of average body weight 21.8 ± 4.8 kg. The prostatic volume was ultrasonographically obtained by using the formula for the volume of an ellipsoid (V_E) or for a box (V_B). The greatest cranio-caudal length (L), transverse width (W) and dorso- ventral depth (D) diameters of the prostate in centimeters were found to be 3.15 ± 0.83, 3.15 ± 0.9 and 2.83 ± 0.60 cm respectively. Prostatic volume was calculated using the formula:

$V_E = 0.524 \times L \times W \times D$ or

$V_B = L \times W \times D$

The prostatic volumes determined sonographically were 16.77 ± 11.77 and 32 ± 22.6 respectively for V_E and V_B. The real prostate volume was found out by water displacement. There was excellent correlation between prostatic volume calculated from ultrasonographic measurements and prostatic volume measured by water displacement. The formula determined in the study was a useful tool for accurate estimation of prostatic size for diagnosis of prostatic disease and for monitoring treatment response in the canine prostate.

Rivero *et al.* (2005) had done experiment in dogs over 5 years of age and obtained ultrasonographic measurements of the prostate as 2-8 cm to 7-11 cm with a median of 5-8cm in big breed dogs.

Ghadiri *et al.* (2007) calculated prostatic volume using the formula for the volume of an ellipsoid and for a box. The study was conducted in 10 intact mongrel dogs. Average prostatic length, depth and width were found to be 3.35 ± 0.4, 3.42 ± 0.53 and 2.78 ± 0.5cm. Highly significant correlation was obtained between prostatic parameters calculated from transabdominal and transrectal ultrasonography and actual dimension.

In a recent study, Gadelha *et al.* (2009) recorded the craniocaudal and ventrodorsal prostatic dimensions in three age groups of dogs. The average ventrodorsal diameter in dogs from one to three years, four to six years and older than 7 years were 2.16 ± 0.89, 3.00 ± 0.78 and 3.00 ± 0.55cm respectively. The average cranio- caudal diameters in those dogs were 2.25 ± 0.89, 3.22 ± 0.01 and 3.84 ± 0.89cm respectively. A positive correlation was found between prostate dimensions and animal age suggesting that the prostatic size increased with age.

2.8. PROSTATIC DISEASES

2.8.1. Common prostatic diseases

The most common prostatic diseases identified by Krawiec and Heflin (1992) were bacterial prostatitis followed by prostatic cyst, prostatic adenocarcinoma and benign hyperplasia. The most common prostatic disease in neutered dogs was prostatic adenocarcinoma.

Henson (2001) separated the canine prostatic illness into infectious and non infectious categories. Infectious prostatic diseases included acute and chronic prostatitis and prostatic abscess. Non infectious prostatic diseases included benign prostatic hyperplasia, prostatic cysts and prostatic neoplasia.

Menon (2004) identified the most common prostatic disease as benign prostatic hyperplasia followed by prostatitis, prostatic atrophy, prostatic adenocarcinoma and squamous metaplasia.

Rivero *et al.* (2005) obtained 50 per cent adenocarcinomas, 12.5 per cent benign prostatic hyperplasia, 12.5 per cent prostatitis, 12.5 per cent prostatic cyst and 12.5 per cent prostatic abscess in 8 of the 20 male dogs examined.

2.8.2. Age and breed predilection for prostatic diseases

Krawiec and Heflin (1992) found the mean age of onset of prostatic disease as 8.9 years. The most common breed with prostatic disease was Doberman pinscher and German shepherd was the second most commonly affected breed. Prostatic diseases were common in older, sexually intact male dogs. Progressive increase in numbers of dogs with prostatic disease was associated with advancing age. The authors observed approximately 8 per cent of all male dogs above 10 years of age had prostatic disease where as 0.6 per cent of male dogs below 4 years old were affected. Symptoms of the prostatic disease could be generally found in dogs older than 5.5 years. Green and Homco (1996) and Kamolpatana *et al.* (2000) found that the prostatic diseases were more common in older dogs especially over 5 years of age.

According to Johnston *et al.* (2001), although there appeared no breed predilection for prostatic disease, large breed dogs such as German shepherd and Doberman had an increased prevalence.

Clinical conditions of prostate were observed in 60 per cent of dogs more than 5 years and in nearly 100 per cent dogs more than 10 to 12 years old (Vestergen and Onclin, 2002)

Menon (2004) noticed that dogs more than five years and dogs between three to five years were most affected with prostatic diseases followed by dogs between one to three years of age and dogs less than one year of age. Among different breeds German shepherds were found to be the most susceptible to prostatic diseases.

Paclikova *et al.* (2006) observed that progression of the prostatic disease commenced in dogs aged 5.5 years or older. Older intact dogs of all breeds were preferably affected.

Barsanti (2008) and Smith (2008) observed that the mean age of diagnosis for dogs with prostatic cancer was 10 years.

Menon (2008) found the average age of the affected animals with prostatic disorders as 8.70 ± 0.76 years with a range of 5-13 years.

2.8.3. Benign prostatic hyperplasia (BPH)

In more than 80% of male dogs over 5 years of age with benign prostatic hyperplasia, prostatic volume was 2 to 6.5 times greater than normal dogs (Johnston *et al.*, 2001 and Memon, 2007).

Sirinarumitr *et al.* (2001) found that more than 80 per cent of sexually intact male dogs over 5 years of age had gross or microscopic evidence of BPH.

Wallace (2001) observed that the BPH was the most common disorder of the canine prostate gland. The disorder developed in older intact male dogs as a natural result of ageing and hormonal influences on the prostate gland. As dogs age, the number of receptors for dihydro testosterone increased, testosterone levels fell and estrogen levels remained unaffected. The altered androgen to estrogen ratio played a role in the development of both glandular hyperplasia and hypertrophy.

White (2005) stated that glandular hyperplasia was a normal physiological process seen in the juvenile dog below 5 years and complex hyperplasia began to appear in the prostate gland beyond the age of 5 years under the influence of 5-di hydro testosterone.

Gradil *et al.* (2006) and Romagnoli (2007) suggested that BPH involved increase in epithelial cell number as well as epithelial cell size with the increase in numbers being more marked. It was the most common canine prostatic disease with almost 100 per cent of intact dogs developing histological evidence of hyperplasia with ageing.

Lobetti (2007) opined that as a dog aged, spontaneous enlargement of the prostate gland occurred which was referred to as BPH. Despite that enlargement, the prostatic secretory capacity decreased as hyperplasia developed. The prostate could undergo both glandular and complex hyperplasia. Glandular hyperplasia developed at 1-2 years of age and its prevalence peaked at 5 - 6 years. Complex hyperplasia developed later but the first evidence appeared at 2-3 years of age.

Parry (2007) found that BPH was the most common prostatic disorder and present either grossly or microscopically in almost 100 per cent sexually intact adult male dogs over the age of seven years. BPH aroused spontaneously in the prostate gland as a consequence of ageing and endocrine influence and might begin as early as 2 -3 years of age, becoming cystic after 4 years of age.

Barsanti (2008) found that hyperplasia was associated with an altered androgen to estrogen ratio and required the presence of testis.

BPH was a spontaneous disease of intact male dogs that appeared as glandular hyperplasia as early as 3 years of age. BPH was the part of an ageing process (Smith, 2008). The initial hyperplasia began as glandular hyperplasia and subsequently transitioned in to cystic hyperplasia which often lead to the formation of cystic structures within the prostate.

Beceriklisoy *et al.* (2010) found that the age of dogs with BPH ranged between 8 and13 years.

2.8.4. Prostatitis

Barsanti and Finco (1979) found that bacterial prostatitis occurred secondary to lower urinary tract diseases such as urolithiasis, trauma, strictures, neoplasia and urinary tract infections or occurred due to diseases of prostate itself such as cysts, neoplasia or squamous metaplasia.

Feldman and Nelson (1996) found that bacterial prostatitis was the most important disorder affecting fertility. Prostatitis caused fever-induced impairment of spermatogenesis, decreased libido due to localized inflammation, pain and systemic illness.

Johnston *et al.* (2001) noticed that prostatitis occurred secondary to diseases of the prostate of intact dogs such as BPH or secondary to diseases of intact or neutered dogs such as prostatic neoplasia. Therefore it was observed in both castrated and intact dogs but was much more common in intact dogs. Age of onset of the disease varied with underlying cause of infection.

Wallace (2001) found that infection of prostate gland was common in older dogs with BPH, and was rare in castrated dogs due to atrophy of the gland. The glandular changes and disruption of normal urine flow and prostatic fluid flow associated with BPH pre disposed the gland to infection.

Vestergen and Onclin (2002) found that bacterial prostatitis was the second most common prostatic disorder in dogs after benign prostatic hyperplasia. Prostatitis was of two types- acute and chronic. Acute prostatitis had multiple clinical signs and chronic prostatitis was not generally accompanied by clinical signs.

Smith (2008) stated that male dogs had sufficient defense mechanisms which protect the prostate from infection. Prostatitis occurred when prostate was compromised by BPH or cysts.

2.8.5. Prostatic cysts

Black *et al.* (1998) evaluated the prevalence of prostatic cysts in 85 adult male dogs weighing more than 16 Kg and average age of 8 years which were admitted for problems unrelated to the prostate gland. Results of the study indicated that the prevalence of prostatic cysts in adult intact male dogs was approximately 14 per cent.

Ruel *et al.* (1998) and Smith (2008) found that prostatic cyst in ageing dogs had been related to glandular hyperplasia and might predispose to infection and abscess formation.

The prostatic cysts were present as multiple cavitary areas within the parenchyma or large fluid filled structures extending in to the abdomen or pelvic canal. Prostatic cysts might occurr as a result of ductal occlusion (Johnston *et al.,* 2001 and Davidson, 2003).

2.8.6. Prostatic abscess

White (2005) opined that abscesssation was an extension of prostatitis in which infected cystic lesions coalesce into larger loculated accumulations of pus.

2.8.7. Prostatic retention cysts / para prostatic cysts

Mattoon and Nyland (1995) noticed that the paraprostatic cysts were attached to the prostate by a thin stalk or broad fibrous adhesions. Communication directly with the prostate gland and urethra could occur.

Johnston *et al.* (2001) defined paraprostatic cysts as cavitating lesions with a distinct wall containing clear to turbid fluid outside the prostatic parenchyma.

Wallace (2001) found that paraprostatic cysts were located in the vicinity of the prostate and not within it. The cysts often might be very large resembling a second urinary bladder on radiograph. They were thin walled and contained sterile fluid with necrotic debris.

White (2005) observed that paraprostatic cysts or discrete cysts were discrete fluid accumulations within the gland capsule of the prostate or in close proximity to it.

Paclikova *et al.* (2007) stated that paraprostatic cysts were single or multiple structures often invading the space in between prostate gland and urinay bladder. They compressed the descending colon and rectum and other pelvic organs.

2.8.8. Prostatic neoplasia

Krawiec and Heflin (1992) found that prostatic cancer was the most common prostatic disorder found in neutered males and they found that this was the only disease identified in male dogs neutered before the onset of prostatic disease.

Wallace (2001) observed that only 5 to 7 per cent of dogs with prosatic disease had prostatic neoplasia.

Vestergen and Onclin (2002) found prostatic neoplasia in both young adult and old animals and were not directly androgen related in dogs. Their appearance and size increase were rapid and metastases were already present when a diagnosis was reached.

Gradil *et al.* (2006), Parry (2007) and Smith (2008) observed the most common neoplasm of the canine prostate as the adenocarcinoma and considered to arise from ductal epithelium.

Kirpensteijn (2008) found that the incidence of prostatic cancer was approximately 0.05 per cent. It was noticed that castrated dogs had a higher incidence of developing prostatic cancer than intact dogs with an increased risk of 2.5 to 5 times.

2.8.9. Diagnosis of prostatic diseases

Barsanti *et al.* (1980), Kraweic and Heflin (1992), Kustritz and Klausner (2000) and Davidson (2003) stated that prostatic disease in dog was diagnosed with history, physical examination, complete blood count and urinalysis.

Burk and Ackerman (1996), Johnston *et al.* (2001), Wallace (2001), Gobello and Corrada (2002), Lobetti (2007), Smith (2008) and Beceriklisoy *et al.* (2010) opined that evaluation of dogs with suspected prostatic disease should include urinalysis, urine culture, serum biochemistry profile, complete blood count, survey radiographs, abdominal ultrasound, semen evaluation, prostatic fluid culture, prostatic fluid cytology, prostatic fine needle aspirate and prostatic needle biopsy.

Kraft *et al.* (2008) opined that the three most common and effective sampling techniques for diagnosis of prostatic disorders included collection of ejaculate fluid, fine needle aspiration and urethral catheterization with prostatic massage.

2.8.9.1. Clinical signs

Kustritz and Klausner (2000) and Davidson (2003) observed that urethral discharge, haematuria and rectal tenesmus, anorexia and lethargy were the most frequent signs in dogs with prostatic disease. An enlarged prostate impinging on the rectum can cause tenesmus or constipation and the faeces may have a ribbon like appearance (Smith, 2008).

The typical history of a male dog with prostatic disease was that the dog aged more than 6 years with either lower urinary tract signs (pollakuria, dysuria, haematuria) and/or lower bowel signs (tenesmus, hematochezia, constipation) according to Wallace (2001). A wide based gait in the hind limbs of some dogs with prostatic disease called 'prostatic shuffle', which was an attempt to ease discomfort while walking, could be observed. The author found decreased libido, hemospermia and reduced fertility in breeding dogs with prostatic diseases.

Paclikova *et al.* (2006) and Menon (2008) observed the major clinical signs as constipation, inappetence, hemorrhagic prepucial discharge, dysuria, abnormal gait, vomiting and cachexia, hematuria, pyuria and purulent prepucial discharge in dogs with prostatic diseases. To confirm the diagnosis rectal palpation, ultrasonography and fine needle aspiration cytology were used.

2.8.9.2. Rectal palpation

A change in prostatic size, consistency, and symmetry could be observed on rectal examination of dogs with BPH (Wallace, 2001 and Freitag *et al.,* 2007).

Gobello and Corrada (2002), Davidson (2003), White (2005) and Romagnoli (2007) found that on digital rectal palpation, the prostate was symmetrically enlarged, smooth, movable and painless in dogs with BPH.

Davidson (2003) and Smith (2008) found that the dogs affected with bacterial prostatitis had a painful prostate on rectal palpation. The prostate was normal in shape, symmetry and with irregular in size and surface conformation. They noticed that the median raphe was not readily identified.

Boland *et al.* (2003), Parry (2007) and Smith (2008) palpated prostate gland per rectum and obtained enlargement in dogs with prostatic cysts and pain was noticed on palpation in some of the dogs.

White (2005), Freitag *et al.* (2007) and Barsanti (2008) palpated the prostate of dogs with prostatic abscess per rectum and found that the gland was asymmetric and the dogs exhibited pain on palpation of the prostate. Barsanti (2008) found irregular enlarged prostate gland adhered to the floor of the pelvis on rectal palpation of dogs with prostatic neoplasia.

Smith (2008) found the prostate was in the pelvic canal in most of the cases but in advanced cases, it was within the abdomen. If a palpable prostate was found on transrectal examination of a castrated male dog, it would be suggestive of prostatic neoplasia.

2.8.9.3. Ultrasonography

Feeney *et al.* (1987) found that ultrasonography of the infected prostate revealed focal or diffuse hypoechoic changes giving the parenchyma a mottled or "moth eaten" appearance.

Bell *et al.* (1991) found that the hyperechoic foci in prostatic neopalsia were either dispersed throughout the parenchyma or confined to focal areas. Hyperechoic foci with acoustic shadowing representing mineralization were observed.

Mattoon and Nyland (1995) noticed that the ultrasonograpic appearance of benign prostatic hyperplasia was subtle in homogeneity of the parenchyma without obvious enlargement. They noticed that the enlargement was symmetrical or non-symmetrical, smooth or nodular distorting the margin of the gland. Diffuse enlargement caused loss of the normal bilobed appearance of the prostate but the capsule of the gland was intact. The echogenicity of the gland varied. It was diffusely homogeneous and hypoechoic to hyperechoic but some degree of inhomogeniety was noted in some cases. Parenchymal texture varied from smooth to coarse. Symmetrical or asymmetrical enlargement was present in bacterial prostatitis depending on whether the disease was focal, multifocal or diffuse. It was found that true prostatic cysts were characterized by anechoic contents surrounded by a thin hyperechoic wall with distal acoustic enhancement. Prostatic cysts varied in size and number.

Burk and Ackerman (1996) noticed that the paraprostatic cysts typically revealed anechoic fluid filled structure with varied wall thickness on ultrasonography. The contents of the cysts had focal echogenicities perhaps demonstrating a swirling movement when agitated with transducer pressure. It was difficult to distinguish a large paraprostatic cyst from the urinary bladder but the distinction was made by careful examination from all sides. An enlarged and irregular gland with heterogeneous echotexture was found ultrasonographically in prostatic neoplasia

Prufer *et al.* (2000) found single or multiple foci of increased echo intensity in prostatitis. Also it produced multifocal anechoic or hypoechoic areas with smooth or irregular margins. Hyperechoic areas that shadow might indicate prostatic mineralization. In prostatic cysts, the anechoic prostatic cysts varied in size from a few millimeters to several centimeters and the remaining parenchyma showed normal texture.

Miyabayushi (2001) observed multiple cavitary areas appeared tubular suggesting dilation of the prostatic ducts in dogs with prostatic cysts.

Wallace (2001) and Parry (2007) observed a symmetrically enlarged uniformly textured enlarged prostate with small hypoechoic or anaechoic cysts in ultrasonography of BPH. The echo intensity of the prostate was normal.

Davidson (2003) noticed small, focal, smoothly marginated areas of decreased echogenicity in cystic hyperplasia. Alterations were observed in the capsule of the prostate gland in prostatic diseases. In BPH, the prostate was uniformly isoechoic to hyperechoic. In prostatic abscess, there was hypoechoic to anaechoic areas in the parenchyma.

Boland *et al.* (2003) noticed prostatic enlargement and cavitary lesions in prostate of dogs with prostatic cyst and abscess. Cavitary lesions ranged from 0.5 to 6.5 cm in diameter. They found that cystic lesions were typically more regular than abscesses and distinct with anechoic fluid in the central areas. Abscesses contained hypoechoic or anechoic fluid in the central areas with the internal margin of cavity typically being irregular.

Barsanti (2006) found solitary or multiple hypoechoic or anechoic lesions in prostatic abscess. Cellular echoes within the cavity might be present. Barsanti (2008) and Beceriklisoy *et al.* (2010) noticed that the prostate in BPH appeared symmetric, smoothly marginated and uniformly isoechoic to hyperechoic.

Davidson and Baker (2009) observed symmetric mild enlargement of the prostate gland with mildly increased echogenecity in BPH. The shape of the gland was changed from bilobed to circular in transverse plane in some of the patients. The parenchyma had striated appearance in some animals. Chronic severe prostatitis had poorly marginated multifocal, mixed echogenecity with infrequent mineralization. It was found that para prostatic cysts had the appearance of a second urinary bladder because they had cranially a round shape and caudally a tapered neck. Their distinct wall had a variable thickness and occasionally mineralized. The prostatic neoplasia was typically multifocal, hyperechoic, poorly marginated and mineralized. Mineralization appeared as highly echogenic slashes with attenuating shadows.

2.8.9.4. Urinalysis

Wallace (2001), Davidson (2003) and Parry (2007) found that the urinalysis of most of the dogs with BPH was normal but in some cases, there were red blood cells and squamous epithelial cells on urinalysis. They suggested that the urine culture should be negative or grow less than 10,000 colonies per milli litre unless the dog has secondary prostatitis.

Wallace (2001), Davidson (2003), Holt (2004), Paclikova *et al.* (2006) and Smith (2008) found that in prostatitis, there was haematuria, pyuria, bacteruria and proteinuria.

Boland *et al.* (2003) obtained the most common organism on urinalysis as *E. coli* in dogs with prostatic abscess but for most of the dogs, the urine cultures were negative.

Parry (2007) observed that urinalysis in prostatic cyst was usually normal but increased erythrocyte count or inflammatory cells might be seen if the cyst communicated with the urethra.

Barsanti (2008) noticed haematuria and atypical cells in urine sediment in dogs with prostatic adenocarcinoma.

2.8.9.5. Prostatic fluid cytology

Davidson (2003) stated that cytology of the prostatic fluid was normal in dogs with BPH, although hemorrhage might be present.

Parry (2007) observed neoplastic epithelial cells on cytological evaluation of prostatic fluid in dogs with prostatic neoplasia.

Kraft *et al.* (2008) found that approximately 0.5 to 1 ml of prostatic fluid was adequate for cytological and microbiological examination. They observed epithelial cells arranged individually or in variably sized clusters in cytology of BPH. The epithelial cells were well differentiated and very similar in appearance to normal prostatic epithelial cells but some exhibited a characteristic mosaic appearance with uniform cell size, abundant basophilic cytoplasm and mature nuclei with small round nucleolus. They opined that a symmetrically enlarged prostate with cytology yielding clumps of well- differentiated prostatic epithelial cells without inflammation was consistent with a diagnosis of BPH.

Smith (2008) observed that cytology revealed inflammatory cells or bacteria in dogs with prostatitis.

Gadelha *et al.* (2009) observed high cellular blocks, augmented nucleus: cytoplasm ratio and more basophilic cytoplasm sometimes with vacuolization in cytology of the prostatic fluid of dogs with BPH.

2.8.9.6. Culture and sensitivity of the prostatic fluid

Barsanti *et al.* (1980) stated that if the results of microbial culture of an ejaculate were positive, the type and number of bacteria must be correlated with cytologic findings before the culture was assessed as significant for infection. They suggested that various species of gram positive organisms in the presence of squamous cells with bacteria or only low numbers of neutrophils indicated that the organisms were urethral or preputial in origin.

Krawiec and Heflin (1992), Wallace (2001), Davidson (2003), White (2005), Paclikova *et al.* (2006) and Gadelha *et al.* (2009) observed *E. coli* as the most common organism in dogs with bacterial prostatitis followed by *Staphylococcus* species and *Klebsiella* species, *Proteus* species and *Pseudomonas* species.

Feldman and Nelson (1996) suggested that infection should be suspected in the prostate gland if large numbers of organisms (greater than 10^5 / ml) were grown especially if they were gram negative or organisms grown in pure culture or if large numbers of bacteria were present.

Boland *et al.* (2003) obtained *E. coli* as the most common organism while culturing the prostatic fluid of dogs with prostatic abscess.

Bacterial cultures were negative or yield low quantitative growth in dogs with BPH according to Davidson (2003).

2.8.9.7. Haematology

Wallace (2001), Davidson (2003), Pacilikova *et al.* (2006) and Smith (2008) observed neutrophilic leukocytosis with left shift in cases of acute prostatitis. The haemogram of dogs with chronic prostatitis was usually normal.

Parry (2007) noticed that haemogram findings were consistent with estrogen toxicity in dogs with BPH and included a non- regenerative anemia, thrombocytopenia, granulocytosis or granulocytopenia. The author further observed that in dogs with prostatic cysts, haemogram was usually normal in dogs although a neutrophilic leukocytosis with or with out a left shift and toxic neutrophil changes might be present.

Barsanti (2008) obtained mild to moderate leukocytosis and lymphopenia in dogs with prostatic abscess.

2.8.9.8. Serum biochemistry

Bell *et al.* (1991) noticed that the most common change on serum chemistry profiles of affected dogs with prostatic disease was elevated alkaline phosphatase. They noticed leukocytosis with left shift and neutrophilia in dogs with prostatic neoplasia.

Serum and seminal acid phosphatase activities did not differ significantly between normal dogs and those with prostatic diseases, or among dogs with different prostatic disorders. Serum canine prostate specific esterase activities were significantly higher in dogs with BPH than in normal dogs. It was suggested that proteins of prostatic origin appeared in the serum of dogs as a result of prostatic pathology, especially BPH (Bell *et al.*, 1994).

Corazza *et al.* (1994) found that dogs with prostatic adenocarcinoma had significantly higher total acid phosphatase, prostatic acid phosphatase and non- prostatic acid phosphatase serum concentrations than dogs with benign prostatic hypertrophy, normal dogs and dogs with non-prostatic disease. Low serum concentrations of total acid phosphatase and prostatic acid phosphatase did not rule out prostatic adenocarcinoma in the dog, but elevated concentrations were useful criteria for the diagnosis of canine prostatic cancer.

Menon (2004) opined that the increased amounts of acid phosphatase in hyperplastic and neoplastic prostates pointed to the fact that prostatic acid phosphatase could be used as a marker for the diagnosis of prostatic cancer.

Freitag *et al.* (2007) and Barsanti (2008) noticed that serum alkaline phosphatase was seen increased in some dogs with prostatic abscess. The latter found that 50 per cent of dogs with prostatic adenocarcinoma had increased serum alkaline phosphatase.

Materials and Methods

3. MATERIALS AND METHODS

3.1. EXPERIMENTAL ANIMALS

The data pertaining to the present investigation were generated from the 56 male dogs presented to the outpatient unit of University Veterinary Hospitals, Mannuthy and Kokkalai, during the period between January 2009 and March 2010. Forty three sexually intact male dogs belonging to four different breeds and ten male dogs with symptoms of prostatic disease were selected for the study. Their general health condition, age and body weight were assessed. After physical examination of the prostate by digital palpation, they were subjected to detailed ultrasonography of the prostate gland. In addition to the above mentioned dogs, the prostate gland of a castrated German shepherd, a castrated Dachshund and a pre-pubertal German shepherd presented to clinics were also assessed ultrasonographically.

3.2. DIGITAL PALPATION OF PROSTATE GLAND

Following general examination of the animal, the prostate of each animal was palpated rectally by the method described by Allen *et al.* (1991) using a gloved finger and the following information about the prostate gland were recorded.

a. Location

b. Symmetry

c. Consistency

d. Mobility and

e. Presence of pain.

3. 3. ULTRASOUND SCANNING

3.3. 1. Equipment

Ultrasound equipment present in Veterinary College Hospital, Mannuthy (DC-6 VET Diagnostic Ultrasound System Mindray, Biomedical Electronics Co. Ltd) and present at University veterinary Hospital, Kokkalai (HS 2000, Honda Electronics Co. Ltd), were utilized for the study. The ultrasonography of prostate was carried out with the linear and sector probes of 5MHz and 7.5MHz frequency respectively (Plate 1 and 2). Both the instruments had facility for real time B- mode ultrasonography.

3.3. 2. Transabdominal scanning

3.3.2.1. Preparation of the animal

The hair in the sub pubic area of the dog (between the cranial aspect of the prepuce and pubic bone from the midline to the inguinal fold on each side) was shaved. The patient was positioned in dorsal or dorso- lateral recumbency and a coupling gel was applied over the skin of the shaved area for improving the contact. As the distended urinary bladder cause visualization of the prostate gland more clearly, infusion of physiological saline in to the bladder by catheterization was done.

3.3.2.2. Ultrasonography

Transabdominal ultrasonography was carried out in all the 56 animals using a 7.5 MHz transabdominal probe. For imaging the gland, the probe was placed against the ventral abdominal wall cranial to the pubis. For the complete visualization of the prostate gland, the probe was turned to transverse and longitudinal planes (Plate 3). After visualization of the prostate gland, the following features were specifically recorded.

a) The echogenicity and regularity of the gland capsule

b) The echogenecity and homogenecity of the prostatic parenchyma

c) Measurement of the prostate in longitudinal and transverse sections

The measurement of the prostate gland was carried as per the protocol given by Atalan *et al.* (1999c). Briefly, each prostate was imaged according to the established protocol using a 7.5 MHz mechanical sector transducer. Standard longitudinal and transverse sections were obtained and prostatic volume and weight were estimated according to the formulae derived by Atalan *et al.* (1999c):

Prostatic volume (in cm^3) = $0.487 \times L \times W \times (DL + DT) / 2 + 6.38$

Prostatic weight (in g) = $0.508 \times L \times W \times (DL + DT) / 2 + 3.21$

[L = maximum length (cm) in longitudinal section, DL= maximum depth (cm) in longitudinal section, W = maximum width (cm) in transverse section, DT = maximum depth (cm) in transverse section]

The mean prostatic measurements for different breeds of dogs were recorded.

3.3.3. Transrectal scanning

Transrectal ultrasonographic examinations were performed using a real time B-mode scanner equipped with linear array transducer in large breeds like German shepherd and Rottweiler. For the purpose of transrectal scanning, the dogs were restrained in standing position. Ultrasound- gel- couplant was applied to the transducer to assure good acoustic transmission. The transducer head was protected with a human condom. The 5 MHz transducer was introduced gently in to the rectum in a downward fashion until the bladder appeared on the screen (Plate 4). After visualization of the prostate gland, the following features were recorded.

a) The echogenicity and regularity of the gland capsule

b) The echogenecity and homogenecity of the prostatic parenchyma

c) Measurement of length and width f the prostate

3.3.4. Comparison of the measurements obtained

The prostatic volume and weight obtained in different breeds of dogs were compared to find whether there was any correlation with breed, body weight and age. The calculated prostatic volume and weight for all dogs were compared with age and body weight.

3.4. PROSTATIC DISEASES

Detailed investigation of prostate was carried out by collecting urine, prostatic fluid and blood in ten prostatic disease suspected animals with clinical symptoms such as constipation and difficulty in urination and in ten normal intact dogs for comparison.

3.4.1. Urinalysis

Urine was collected by catheterization. All aseptic conditions were followed. The prepuce and glans penis were cleaned with sterile gauge. The sterile catheter sized 5/6 was passed through the tip of the penis up to the bladder without applying much force. The urine was collected by withdrawing it into a sterile syringe. Physical, chemical and microscopical evaluations of urine were performed as per the procedure given by Chauhan *et al.* (2006) just after its collection. In physical examination, the colour, turbidity and specific gravity of the urine sample were assessed. In chemical examination, pH of urine, presence of protein, haemoglobin and blood were assessed. For microscopical examination, urine was centrifuged at 1000rpm for 10 minutes. The supernatant was discarded and a drop of sediment was placed on the middle of a clean and dry glass slide. It was covered with a cover slip and examined under microscope for epithelial cells, leucocytes, erythrocytes and bacteria. For cultural examination, urine was collected in a sterile container and inoculated directly on the culture media. Presence of bacterial growth was assessed.

3.4.2. Evaluation of the prostatic fluid

The prostatic fluid from the ten disease suspected animals and ten normal animals which had responded to digital manipulation was obtained by the procedure described by Johnston *et al.* (2001). Briefly, the male dog was properly restrained and the penis was gently massaged through the prepuce. The prepuce was retracted caudally behind the bulbus glandis and digital pressure was applied immediately behind the bulbus glandis by encircling the penis using a gloved thumb and index finger. The animal was allowed to ejaculate the first and the second fraction of the semen and the third fraction comprising the prostatic fluid were collected into separate sterile collection tubes (Plate 5). The prostatic fluid so obtained was subjected to the cytological and culture and sensitivity tests.

3.4.3. Haematological studies

3.4.3.1. Blood collection

Five ml of blood was collected from either cephalic vein or saphenous vein. Sodium citrate 3.8 per cent at the rate of 1ml/9ml blood was used as the anticoagulant. Plasma separated from 2ml of blood by centrifuging at 3000rpm for 30 minutes and deep freezed at -20°C till the assay (Benjamin, 2001).

3.4.3.2. Haematological parameters

Estimation of total erythrocyte and leucocyte count, differential leucocyte count, packed cell volume (PCV), erythrocyte sedimentation rate (ESR) and haemoglobin concentration were done as per the standard procedures (Schalm *et al.*, 1975).

3.4.3.3. Serum biochemistry

Assay of serum alkaline phosphatase was with ELISA test described by Allen *et al.* (2000). Assay of serum acid phosphatase was with spectrophotometric method described by Corazza *et al.* (1994).

3.5. STATISTICAL ANALYSIS

Data obtained were compiled and analyzed using standard statistical procedures (Snedecor and Cochran, 1994).

Plate 1. Mindray DC-6 VET ultrasound equipment with the ultrasound probes, display and controls

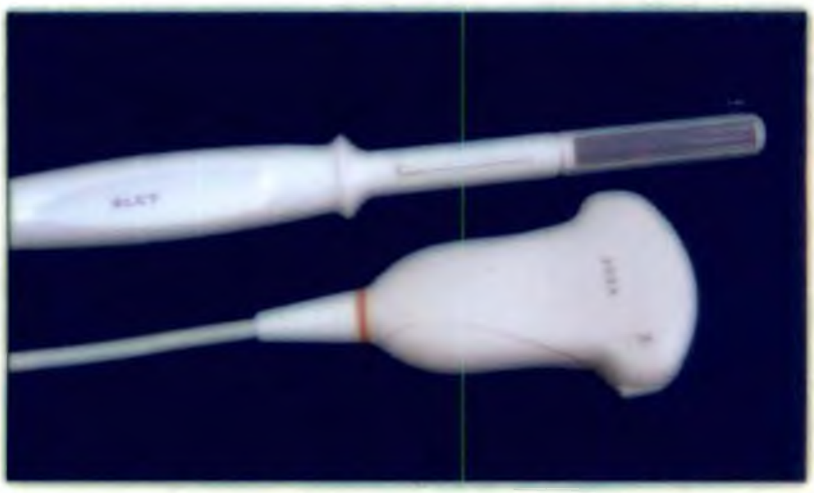

Plate 2. Transabdominal (sector) and transrectal (linear) ultrasound probes

Plate 3. Transabdominal ultrasound scanning of prostate of an German Shepherd dog in dorso- lateral recumbency using Honda HS 2000 ultrasound equipment.

Plate 4. Transrectal scanning of prostate with the animal in standing position using Mindray DC-6 VET ultrasound equipment

Plate 5. Collection of prostatic fluid from a dog by digital manipulation of the penis

Results

4. RESULTS

The study was carried out to evaluate the prostate gland in adult male dogs and to record its biometry using ultrasonography, to correlate various prostatic parameters with breed, age and body weight and to ascertain the prevalence of prostatic disorders among adult dogs.

4.1. DIGITAL EXAMINATION FINDINGS OF PROSTATE

Fifty six dogs of four different breeds were subjected to digital palpation of the prostate.

4.1.1. Location of the prostate gland

On per rectal digital palpation, it was found that the position of normal prostate gland in 78.26 per cent dogs was intrapelvic, 19.57 per cent was positioned partly in the pelvic cavity and partly in the abdominal cavity and the prostate gland of 2.17 per cent of the animals was in the abdominal cavity (Table 1). In diseased animals, 50 per cent had prostate gland partly in pelvic cavity and partly in abdominal cavity and 50 per cent of them had the prostate in abdominal cavity (Table 2).

4.1.2. Symmetry of the prostate gland

The prostate gland was symmetrical in all the normal animals (Table1). In diseased animals 50 per cent had an asymmetrical prostate gland while in 50 per cent it was symmetric (Table 2).

4.1.3. Consistency of the prostate gland

Consistency of the gland in apparently healthy adult dogs (84.78 per cent) was smooth and firm while in castrated and prepubertal males (15.22 per cent), it had a soft consistency (Table 1). In prostatic disease suspected animals, the consistency of the gland was hard in 60 per cent, smooth and firm in 20 per cent and soft in 20 per cent. (Table 2).

4.1.4. Mobility of the prostate gland

In all the normal dogs examined, the prostate gland was movable (Table 1). In prostatic disease suspected animals, prostate gland was fixed upon digital examination in 60 per cent while it was mobile in 40 per cent (Table 2).

4.1.5. Pain on palpation of the prostate gland

In all normal dogs, the per rectal palpation of the prostate gland evinced no pain (Table 1). Pain on palpation was present in only 10 per cent of the diseased animals, whereas it was absent in the remaining 90 per cent (Table 2).

4.2. PROSTATE GLAND EVALUATION BY ULTRASONOGRAPHY

The prostate gland in all dogs was examined ultrasonographically and the following results were obtained.

4.2.1. Capsule of the prostate gland

The normal prostatic capsule was visualised as a uniform, slightly hyperechoic thickening all around the periphery of the prostate gland (Plate 6). In 76.09 per cent of the normal animals and 80 per cent of the diseased animals, the capsule of the prostate gland appeared normal and echogenic. In 23.91 per cent of the normal animals, the capsule could not be detected (Table 3). Irregular prostatic capsule was observed in 20 per cent of the animals (Table 4 and Plate 7).

4.2.2. Parenchyma of the prostate gland

Homogenic prostatic parenchyma was obtained in 95.65 per cent of the normal animals examined (Table 3 and Plate 6). In two castrated animals (4.35 per cent), the prostatic parenchyma appeared slightly hypoechoic (Plate 8). Presence of hypoechoic areas of various sizes (cyst) in the moderately hyperechoic parenchyma of the gland was detected in 20 per cent of the diseased animals but the rest 80 per cent of the animals had normal moderately hyperechoic parenchyma (Table 4).

4.2.3. Transabdominal ultrasonography of the prostate

4.2.3.1. German shepherd

In German shepherd dogs, the mean age of the examined animals was 4.03 years and the mean body weight was 24.21 kg. The mean depths in longitudinal (Plate 6) and tranverse sections (Plate 9) were 3.34 ± 0.12 and 3.61 ± 0.14 respectively. The mean length in longitudinal section was 3.69 ± 0.01 and the width in transverse section was 3.17 ± 0.15. The mean Prostatic volume and weight based on formula calculation were 26.62 ± 1.58 and 24.33 ± 1.65 respectively. The mean prostatic measurements and the calculated prostatic volume and weight and coefficient of correlation (Fig 2) are presented in Table 5 and 6. There was good correlation ($p<0.01$) between age and prostatic volume, prostatic weight and body weight and prostatic volume and prostatic weight. The ultrasonographic details of the prostate of a cryptorchid German shepherd was collected and presented in Plate 10.

4.2.3.2. Rottweiler

The mean age of the Rottweiler dogs examined was 3.35 years and the mean body weight was 35.25 kg. The mean depths in longitudinal (Plate 11) and transverse sections (Plate 12) were 3.36±0.12and 3.74±0.28 respectively. The mean length in longitudinal section was 3.65±0.22 and the mean width in transverse section was 3.04±0.01. Calculated mean prostatic volume and weight were 26.32±2.55 and 24.01±2.66 respectively.

The mean prostatic measurements and the calculated prostatic volume and weight and coefficient of correlation (Fig. 3) were presented in Table 5 and 7. There was good correlation ($p<0.01$) between age and prostatic volume and prostatic weight.

4.2.3.3. Dachshund

The mean age and body weight of the examined Dachshund dogs was 3.94 years and 8.71 kg respectively. The mean depths in longitudinal and tranverse sections were 2.74±0.17 and 2.45±0.15 respectively. The mean length in longitudinal section (Plate 13) was 2.33±0.14 and the mean width in transverse section (Plate 14) was 2.15±0.18. Calculated mean prostatic volume and weight were 13.07±0.96 and 10.89±0.10 respectively.

The mean prostatic measurements and the calculated prostatic volume and weight and coefficient of correlation (Fig. 4) were presented in Table 5 and 8. There was good correlation ($p<0.01$) between age and prostatic volume., prostatic weight and body weight and prostatic volume and prostatic weight.

4.2.3.4. Spitz

In Spitz, the mean age was 2.95 years and the mean body weight was 5.46 kg. The mean depths in longitudinal and tranverse sections were 2.15±0.00 and 2.49±0.01 respectively. The mean length in longitudinal section (Plate 15) was 2.38±0.07 and the width in transverse section (Plate 16) was 1.94±0.01. Calculated mean prostatic volume and weight were 11.63±0.24 and 8.71±0.25 respectively.

The mean prostatic measurements and the calculated prostatic volume and weight and coefficient of correlation (Fig. 5) were presented in Table 5 and 9. There was good correlation at 0.01 levels with body weight and prostatic volume and prostatic weight. The correlation was significant ($p<0.05$) between age and prostatic volume and prostatic weight.

When considering the whole of the adult normal dogs examined, the mean age was 3.59±0.32 years and the mean body weight was 19±1.81 kg. The mean depths in longitudinal and tranverse sections were 2.94±0.01cm and 3.14±0.13cm respectively. The mean length in longitudinal section was 3.09±0.12 and the mean width in transverse section was 2.64±0.11. Calculated mean prostatic volume and weight were 20.23±1.34 and 17.66±1.41 respectively (Table 10).

The coefficients of correlations for the measurements of all the animals were presented in the Table 11 and Fig.6. From the study, it was found that the age and body weight of the animal and the prostatic volume and weight were positively correlated ($p< 0.01$).

4.2.3.5. Castrated animals

One Dachshund and one German shepherd (Plate 8) were examined ultrasonographically and their measurements (Table 12) were compared with the mean prostatic measurements of the respective breeds. The measurements were found less than the mean prostatic measurements.

4.2.3.6. Pre -pubertal animal

One German shepherd dog of five months age was examined ultrasonographically (Plate 17) and their measurements (Table 13) were compared with the mean prostatic measurements of the respective breed. The measurements were found less than the mean prostatic measurements.

4.2.3.7. Disease suspected animals

The dogs suspected for prostatic disorders were screened ultrasonographically and their volume and weight were calculated and the mean values were obtained. The mean age was 6.67 years and the mean body weight was 20.35kg. In six cases, there were prostatic enlargement found ultrasonographically. In them, the mean depths in longitudinal and tranverse sections were 3.88±0.18cm and 4.52 ± 0.48 respectively. The mean length in longitudinal section was 4.18±0.42 and the mean width in transverse section was 3.87±0.34. Calculated mean prostatic volume and weight were 42.73±8.46 and 41.12±8.82 respectively. The mean prostatic measurements and the calculated prostatic volume and weight and coefficient of correlation (Fig. 7) were presented in Table 5 and 14. It was found that the measurements in six dogs were greater than those obtained for the normal animals and that suggested prostatic diseases. In two of those animals, there were multiple anechoic areas in the prostatic parenchyma and were suggestive of prostatic cyst and abscess (Plate 18 and Plate 19). The other four animals suffered from benign prostatic enlargement (Plate 20).

No significant correlations were obtained between age or body weight with prostatic measurements in diseased animals.

Significant difference for prostatic volume and weight was obtained for the four different breeds German shepherd, Rottweiler, Spitz and Dachshund (Fig. 1). It was noticed that the prostatic volume and weight were greater in German shepherd followed by Rottweiler, Dachshund and Spitz. Also there was significant difference for the prostatic volume and weight between the diseased and non diseased animals.

4.2.4. Transrectal ultrasonography of prostate

4.2.4.1. Large breed dogs

The mean prostatic length and width obtained for German shepherd (Plate. 21) were 2.95±0.10cm and 2.44±0.15 respectively. For Rottweiler (Plate 22), the mean prostatic length and width were 2.92±0.15cm and 2.42±0.17 respectively (Table 15). The coefficient of correlation was presented in Table 16 and Table17.

4.2.4.2. Pre- pubertal German shepherd

The transrectal ultrasonographic measurements of the prostate of a pre-pubertal German shepherd were (Table 18 and Plate 17) found lesser than those obtained for normal German shepherd dog.

4.3. PROSTATIC DISORDERS

Among the 56 dogs presented in the clinics during the period from January 2009 to March 2010, six animals (10.71 per cent) were found having prostatic disorders *viz*: four with benign prostatic hyperplasia (7.14 per cent), one with prostatic cyst (1.79 per cent) and one with prostatic abscess (1.79 per cent).

4.4. DETAILS OF CLINICAL INVESTIGATION

4.4.1. Urinalysis

In all animals, the urinalysis was found normal. The colour of urine was yellow and was clear in most of the dogs. The specific gravity and pH were within the normal range. Details of chemical and microscopical examinations were presented in Table 19. The culture and sensitivity was found negative in all dogs examined.

4.4.2. Prostatic fluid cytology

In 40 per cent of the diseased dogs there were presence of neutrophils and in 30 per cent of them, there were few erythrocytes (Table 20).

4.4.3. Culture and sensitivity of prostatic fluid

In all the 20 dogs, culture of the prostatic fluid did not yield any microbial growth (Table 20).

4.4.4. Haematological studies

4.4.4.1. Haemogram

The mean erythrocyte count obtained for the normal and diseased animals were 3.33±1.06 and 3.89±1.41 respectively (Table21). It was found that there were no significant difference between the total erythrocyte counts of normal and disease suspected animals.

4.4.4.2. Leucogram

It was found that the leucocyte counts of all the normal animals and nine disease suspected animals were within the normal limits and the mean leucocyte count in them was 9485.33±1825 and 9854± 1921 respectively (Table 21). In one dog, the leucocyte count was greater than normal (24300/micro litre) and there was leukocytosis with a left shift (neutrophil count 86 per cent with 516 band forms/ micro litre) which was confirmed as prostatic abscess later (Table 22).

4.4.4.3. Serum biochemistry

The mean values for serum alkaline phosphatase were found as 55.53±11.06 units and 62±9.6 respectively in normal and diseased dogs. The mean values for serum acid phosphatase in normal and diseased dogs were 4.85±1.96 and 4.74±2.10 respectively. Both the values were found to be within the normal range in all the dogs examined (Table 23).

Table 1. Prostatic features (percentage) observed on digital palpation in normal dogs (n=46)

		Number of animals	Percentage
Location of the gland			
	Intrapelvic	36	78.26
	Intraabdominal	1	2.17
	Partly pelvic and partly Abdominal	9	19.57
Symmetry			
	Symmetrical	46	100
Consistency			
	Smooth and firm	39	84.78
	Soft	7	15.22
Mobility			
	Movable	46	100
Pain on palpation			
	Painless	46	100

Table 2. Prostatic features (percentage) observed on digital palpation in diseased dogs(n=10)

	Number of animals	Percentage
Location of the gland		
Intraabdominal	5	50
Partly pelvic and partly Abdominal	5	50
Symmetry		
Symmetrical	5	50
Asymmetrical	5	50
Consistency		
Hard	6	60
Smooth and firm	2	20
Soft	2	20
Mobility		
Movable	4	40
Fixed	6	60
Pain on palpation		
Painless	9	90
Painful	1	10

Table 3. Ultrasonographic findings of prostate gland in normal dogs (n= 46)

	Number of animals	Percentage
Prostatic capsule		
Normal and echogenic	35	76.09
Not detected	11	23.91
Prostatic parenchyma		
Normal and homogenic	44	95.65
Hypo echoic	2	4.35

Table 4. Ultrasonographic findings of prostate gland in diseased dogs (n= 10)

	Number of animals	Percentage
Prostatic capsule		
Normal and echogenic	8	80
Irregular	2	20
Prostatic parenchyma		
Normal and homogenic	8	80
Cystic	2	20

Table 5. Mean (±SE) prostatic measurements of dogs obtained on Transabdominal scanning

	Age (years)	Body weight (kg)	Depth in longitudinal section(cm)	Depth in transverse section (cm)	Length in longitudinal section (cm)	Width in transverse section(cm)	Volume of prostate (cm^3)	Weight of prostate (g)
German shepherd n=14	4.03	24.21	3.34±0.12 [c]	3.62±0.14 [b]	3.6950±0.01 [b]	3.17±0.16 [b]	26.62±1.58 [b]	24.33±1.65 [b]
Rottweiler n=10	3.35	35.25	3.36±0.12 [c]	3.74±0.28 [b]	3.6480±0.22 [b]	3.04±0.01 [b]	26.32±2.55 [b]	24.01±2.66 [b]
Daschund n=9	3.94	8.71	2.74±0.17 [b]	2.45±0.15 [a]	2.33±0.14 [a]	2.15±0.18 [a]	13.07±0.96 [a]	10.89±0.10 [a]
Spitz n=10	2.95	5.46	2.15±0.00 [a]	2.49±0.01 [a]	2.38±0.01 [a]	1.94±0.01 [a]	11.63±0.24 [a]	8.71±0.25 [a]
Diseased n=6	6.67	20.35	3.88±0.18 [d]	4.52±0.48 [c]	4.18±0.42 [b]	3.87±0.34 [c]	42.73±8.46 [c]	41.12±8.82 [c]

Means with different superscript differ significantly ($P<0.05$)
Volume and weight of prostate gland were calculated by the formula given by Atalan *et al.* (1999c).

Table 6. Correlation coefficients of Transabdominal ultrasonographic prostatic measurements in German shepherd (n=14)

	Coefficient of correlation	
	Age	Body weight
Depth in longitudinal section	0.537*	0.550*
Depth in transverse section	0.428NS	0.469NS
Length in longitudinal section	0.463NS	0.699**
Width in transverse section	0.774**	0.864**
Volume of prostate	0.845**	0.958**
Weight of prostate	0.845**	0.958**

** Correlation is significant (P<0.01)
* Correlation is significant (P<0.05)
NS Not significant

Table 7. Correlation coefficients of Transabdominal ultrasonographic prostatic measurements in Rottweiler (n=10)

	Coefficient of correlation	
	Age	Body weight
Depth in longitudinal section	0.926^{**}	0.043^{NS}
Depth in transverse section	0.977^{**}	0.112^{NS}
Length in longitudinal section	0.924^{**}	0.338^{NS}
Width in transverse section	0.473^{NS}	0.760^{*}
Volume of prostate	0.978^{**}	0.378^{NS}
Weight of prostate	0.978^{**}	0.378^{NS}

** Correlation is significant (P<0.01)
* Correlation is significant (P<0.05)
^{NS} Not significant

Table 8. Correlation coefficients of Transabdominal ultrasonographic prostatic measurements in Dachshund (n=9)

	Coefficient of correlation	
	Age	Body weight
Depth in longitudinal section	0.608^{NS}	0.668^{*}
Depth in transverse section	0.755^{*}	0.742^{*}
Length in longitudinal section	0.749^{*}	0.746^{*}
Width in transverse section	0.509	0.770^{*}
Volume of prostate	0.813^{**}	0.905^{**}
Weight of prostate	0.814^{**}	0.906^{**}

** Correlation is significant ($P<0.01$)
* Correlation is significant ($P<0.05$)
^{NS} Not significant

Table 9.Correlation coefficients of Transabdominal ultrasonographic prostatic measurements in Spitz (n=10)

	Coefficient of correlation	
	Age	Body weight
Depth in longitudinal section	-0.334^{NS}	-0.528^{NS}
Depth in transverse section	-0.207^{NS}	0.417^{NS}
Length in longitudinal section	0.500^{NS}	0.874^{**}
Width in transverse section	0.949^{**}	0.438^{NS}
Volume of prostate	0.680^{*}	0.853^{**}
Weight of prostate	0.711^{*}	0.831^{**}

** Correlation is significant (P<0.01)
* Correlation is significant (P<0.05)
^{NS} Not significant

Table 10. Mean (±SE) measurements of prostate gland on Transabdominal scanning of all dogs (n= 43)

Age (years)	Body weight (kg)	Depth in longitudinal section(cm)	Depth in transverse section(cm)	Length in longitudinal section(cm)	Width in transverse section(cm)	Volume of prostate(cm^3)	Weight of prostate(g)
3.59±0.32	19.00±1.81	2.94±0.0096	3.14±0.1253	3.09±0.1207	2.64±0.1064	20.23±1.34	17.66±1.40

Table 11. Correlation coefficients of ultrasonographic prostatic measurements in normal dogs (n=43)

	Coefficient of correlation	
	Age	Body weight
Depth in longitudinal section	0.431**	0.740**
Depth in transverse section	0.377*	0.730**
Length in longitudinal section	0.356*	0.821**
Width in transverse section	0.489**	0.812**
Volume of prostate	0.489**	0.841**
Weight of prostate	0.489**	0.840**

** Correlation is significant ($P<0.01$)
* Correlation is significant ($P<0.05$)

Table 12. Transabdominal ultrasonographic measurements of prostate of castrated Dogs (n=2)

	Age (years)	Body weight (kg)	Depth in longitudinal section(cm)	Depth in transverse section(cm)	Length in longitudinal section(cm)	Width in transverse section(cm)	Volume of prostate(cm^3)	Weight of prostate(g)
Dachshund	3	8	1.79	2.39	2.29	1.6	10.11	7.1
German shepherd	4.5	26	2.36	1.98	2.12	1.86	10.54	7.56

Table 13. Transabdominal ultrasonographic measurements of prostate in a pre pubertal German shepherd dog (n=1)

Age (months)	Body weight (kg)	Depth in longitudinal section(cm)	Depth in transverse section(cm)	Length in longitudinal section(cm)	Width in transverse section(cm)	Volume of prostate(cm^3)	Weight of prostate(g)
5	16	1.72	1.82	2.44	2.64	11.93	9.0

Table 14. Correlation coefficients of ultrasonographic prostatic measurements in diseased dogs (n=6)

	Coefficient of correlation	
	Age	Body weight
Depth in longitudinal section	0.255^{NS}	0.263^{NS}
Depth in transverse section	0.525^{NS}	0.913^{*}
Length in longitudinal section	0.576^{NS}	0.848^{*}
Width in transverse section	0.393^{NS}	0.961^{**}
Volume of prostate	0.518^{NS}	0.890^{*}
Weight of prostate	0.518^{NS}	0.890^{*}

* Correlation is significant (P<0.05)
NS Not significant

Table 15. Transrectal ultrasonographic measurements of prostate in German shepherds and Rottweiler

	Age (years)	Body weight(kg)	Length(cm)	Width(cm)
German shepherd (n=10)	4.03	24.21	2.95±0.1023	2.44±0.1554
Rottweiler (n=10)	3.35	35.25	2.92±0.1546	2.42±0.1703
Mean ± standard error	3.73±0.48	28.38±1.4	2.94±0.0085	2.43±0.1127

Table 16. Correlation coefficients of Transrectal ultrasonographic prostatic measurements in German shepherd (n=14)

	Coefficient of correlation	
	Age	Body weight
Length of prostate	0.484[NS]	0.619*
Width of prostate	0.640*	0.501[NS]

* Correlation is significant (P<0.05)
NS Not significant

Table 17. Correlation coefficients of Transrectal ultrasonographic prostatic measurements in Rottweiler (n=10)

	Coefficient of correlation	
	Age	Body weight
Length of prostate	0.780**	-0.078^{NS}
Width of prostate	0.788**	0.013^{NS}

** Correlation is significant (P<0.01)
^{NS} Not significant

Table 18. Transrectal ultrasonographic measurements of prostate in a pre pubertal German shepherd

	Age (months)	Body weight(kg)	Length(cm)	Width(cm)
Immature German shepherd	5	16	1.41	1.23

Table 19. Urinalysis findings of normal and disease suspected dogs

Dogs examined	Physical examination	Chemical examination				Microscopic examination			
	Specific gravity	pH	Protein	Blood	Haemoglobin	Epithelial cells(cells/hpf)	leucocytes (cells/hpf)	erythrocytes (cells/hpf)	bacteria
Normal N=10	1.026±0.01	6.52±0.29	-	-	-	0.8±1.03	0.4± 0.70	0.3±0.67	-
Disease suspected N=10	1.029±0.01	6.42±0.38	-	-	-	1.6±1.58	1.1±1.2	0.6± 0.84±	-

Table 20. Prostatic fluid cytology and culture and sensitivity of normal and disease suspected dogs

	Presence of leucocytes	Presence of erythrocytes	Culture and sensitivity
Normal n=10	2	1	No growth
Percentage	20	10	100
Diseased n=10	4	3	No growth
Percentage	40	30	100

Table 21. Haematology of normal and disease suspected dogs

	TEC	TLC	Neutrophil	Eosinophil	Monocyte	Lymphocyte	Hemoglobin	ESR	PCV
Normal n=10	3.33±1.06	9485±1825	57.7±6.01	2.67±1.11	1.28±0.11	39.73±6.52	13.20±0.73	2. 84±0.82	34.05±1.96
Diseased n=10	3.89±1.41	9854±1921	60.1±4.23	2.40±1.14	1.14±0.49	38.34±4.54	12.89±0.54	2.5±0.3	39±1.34

Table 22. Haematology of dog with prostatic abscess (n=1)

TEC	TLC	Neutrophil	Neutrophil band forms	Eosinophil	Monocyte	Lymphocyte	Hemoglobin	ESR	PCV
3.2	24300	86	516	1	2	11	14	2.83	27

Table 23. Serum biochemistry in normal and disease suspected dogs

Enzyme	Alkaline phosphatase	Acid phosphatase
Normal animals (n=10)	55.53±11.06	4.847± 1.958
Disease suspected dogs (n=10)	62±9.6	4.74±2.10

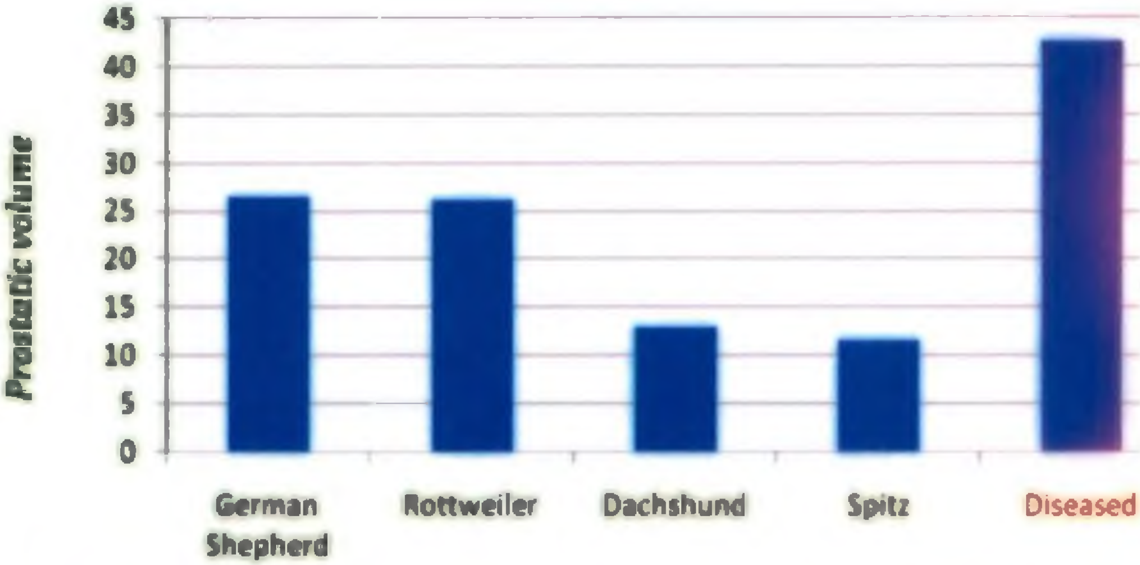

Fig. 1. Comparison of prostatic volume (in cm^3) among diffrrent breeds of dogs

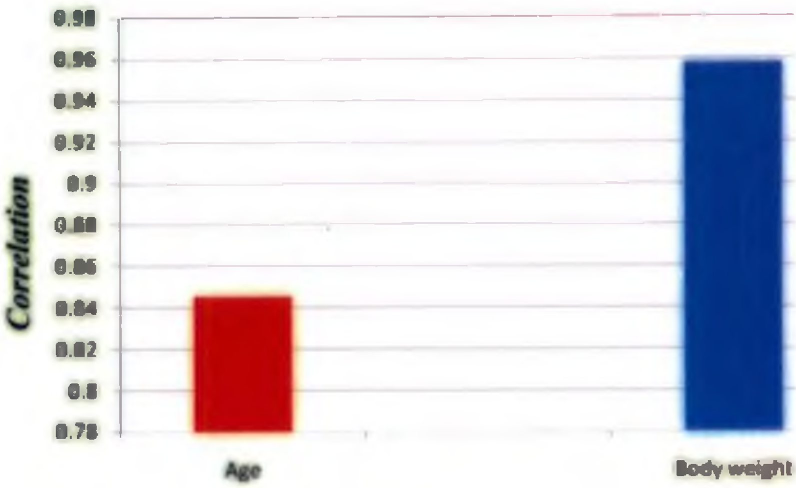

Fig. 2. Correlation between a) prostatic volume and age, b) prostatic volume and body weight in German shepherd dogs

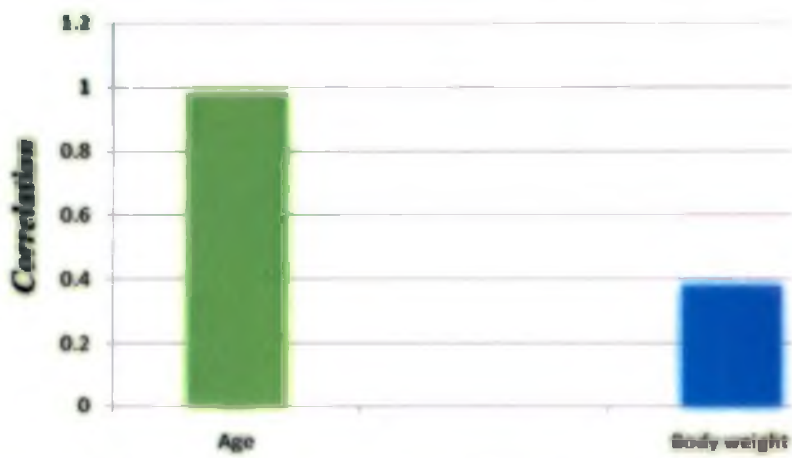

Fig. 3. Correlation between a) prostatic volume and age, b) prostatic volume and body weight in Rottweiler dogs

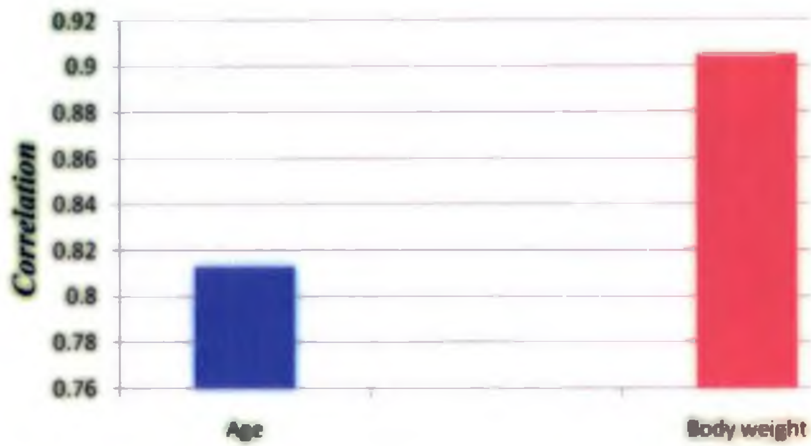

Fig. 4. Correlation between a) prostatic volume and age b) prostatic volume and body weight in Dachshund dogs

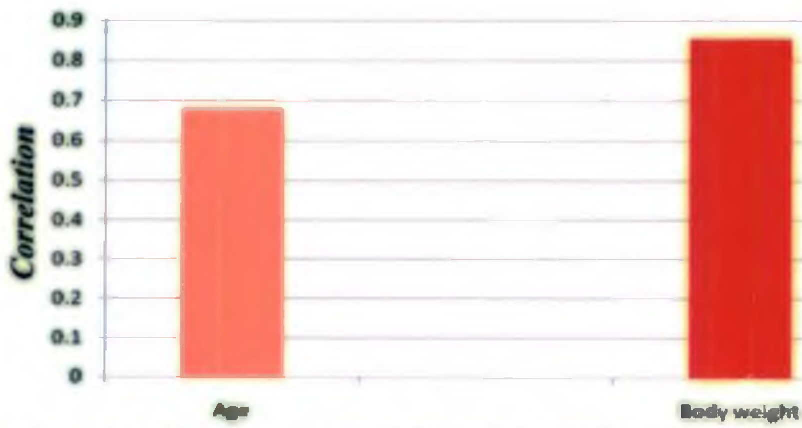

Fig. 5. Correlation between a) prostatic volume and age b) prostatic volume and body weight in Spitz dogs

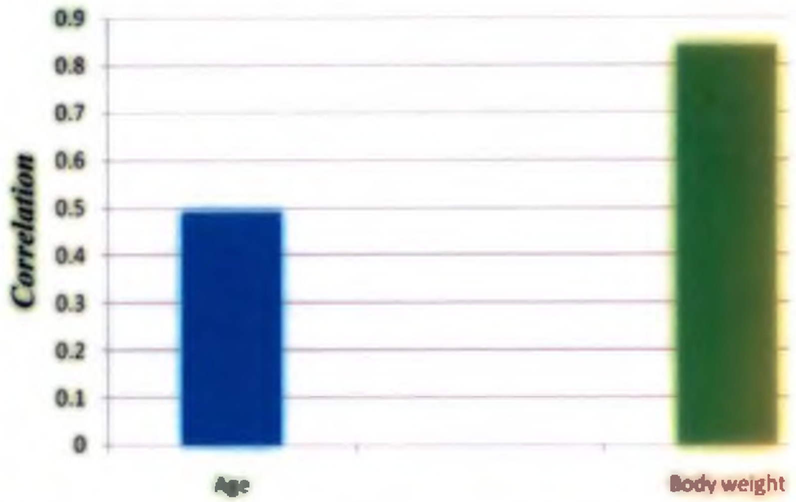

Fig. 6. Correlation between a) prostatic volume and age b) prostatic volume and body weight among all the normal dogs studied

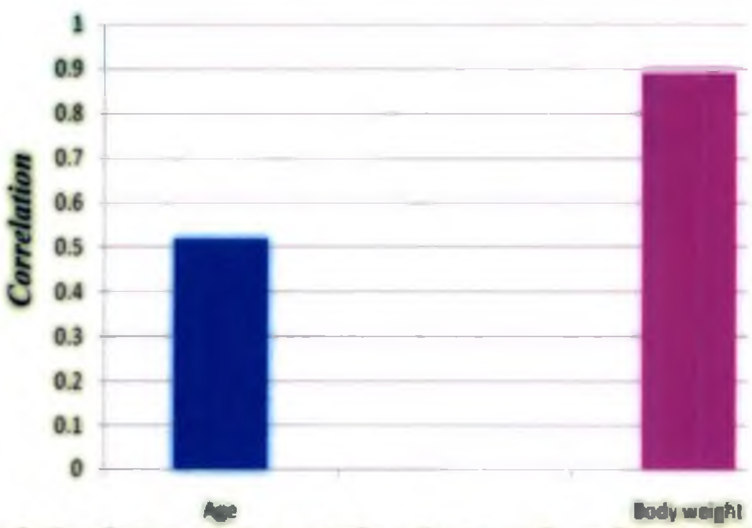

Fig. 7. Correlation between a) prostatic volume and age b) prostatic volume and body weight in diseased dogs

Plate 6. Transabdominal sonogram of prostate of an adult German shepherd in longitudinal section. The intact capsule (C) and the homogeneous parenchyma (P) can be seen Measurement 1 indicates length (L) and 2 indicates depth (DL)

Plate 7. Transabdominal ultrasonogram of prostate of a German shepherd with prostatic abscess. The irregular prostatic capsule can be seen (C)

Plate 6. Transabdominal sonogram of prostate of an adult German shepherd in longitudinal section. The intact capsule (C) and the homogeneous parenchyma (P) can be seen Measurement 1 indicates length (L) and 2 indicates depth (DL)

Plate 8.Transabdominal sonogram of prostate of a castrated German shepherd in longitudinal section. The slightly hypoechoic parenchyma (P) and urinary bladder (UB) can be seen

Plate 9. Transabdominal sonogram of prostate of an adult German shepherd in transverse section. The two lobes of prostate can be seen. The hypoechoic area(G) between the lobes represents glandular parenchyma Measurement marked 1 indicates depth and 2 indicates width.

Plate 10.Transabdominal sonogram of prostate of a cryptorchid German shepherd in longitudinal section. The urinary bladder (UB) and Testicle (T) can be seen along with the prostate (P)

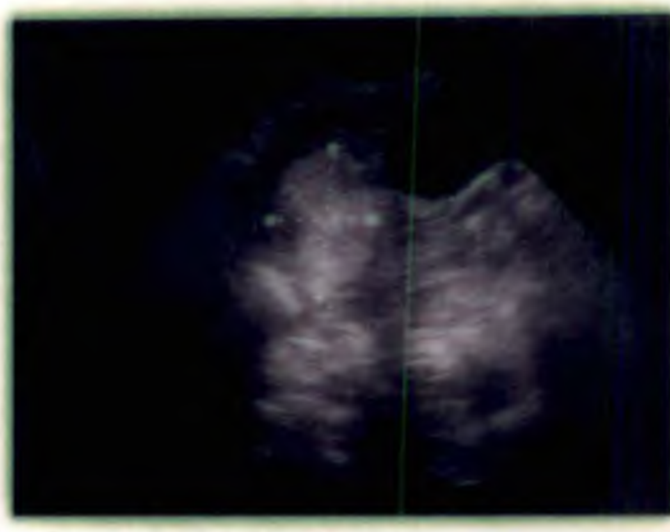

Plate 11.Transabdominal sonogram of prostate (P) of an adult Rottweiler in longitudinal section. The urinary bladder (UB) can be seen Measurement 1 indicates length (L) and 2 indicates depth (DL)

Plate 12. Transabdominal sonogram of prostate of an adult Rottweiler in transverse section. The two lobes of prostate (P1 & P2) and urinary bladder (UB) can be seen. Measurement marked 1 indicates depth and 2 indicates width.

Plate 13. Transabdominal sonogram of prostate (P) of an adult Dachshund in longitudinal section. The neck of the urinary bladder (UB) can be seen. Measurement marked 1 indicates length and 2 indicates depth

Plate 14. Transabdominal sonogram of prostate of an adult Dachshund in transverse section. The two lobes of prostate can be seen. The hypoechoic area(G) between the lobes represents glandular parenchyma. The two lobes of prostate (P1 & P2) and urinary bladder (UB) can be seen. Measurement marked 1 indicates depth and 2 indicates width.

Plate 13. Transabdominal sonogram of prostate (P) of an adult Spitz in longitudinal section. The neck of the urinary bladder (UB) can be seen. Measurement marked 1 indicates depth and 2 indicates length

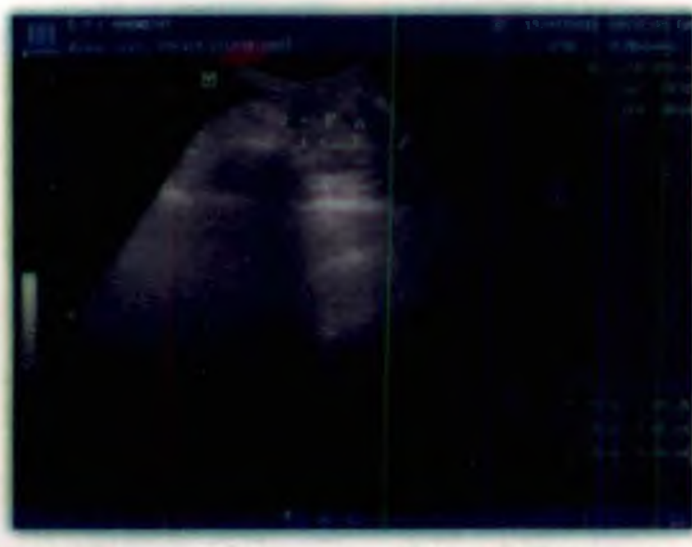

Plate 14. Transabdominal sonogram of prostate of an adult Spitz in transverse section. The two lobes of prostate can be seen. The hypoechoic area(G) between the lobes represents glandular parenchyma. The two lobes of prostate (P1 & P2) and urinary bladder (UB) can be seen. Measurement marked 1 indicates depth and 2 indicates width.

Plate 17.Transabdominal sonogram of prostate of a pre pubertal German shepherd in transverse section. The neck of the urinary bladder (UB) and the two lobes of prostate (P1 & P2) can be seen.

Plate 18.Transabdominal sonogram of prostate of a German shepherd with prostatic cyst. longitudinal section. The anechoic area (arrow) represents cyst.

Plate 19.Transabdominal sonogram of prostate of a German shepherd with prostatic abscess in longitudinal section. The anechoic area (arrow) represents abscess

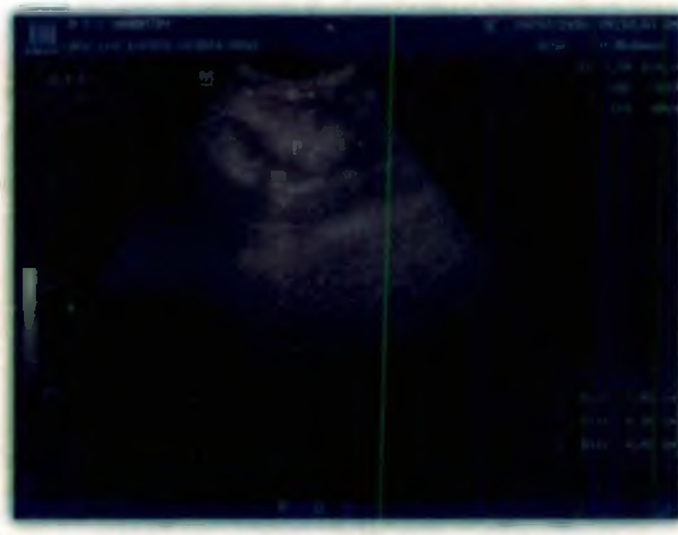

Plate 20 . Transabdominal ultrasonogram of German shepherd with benign prostatic hyperplasia. The enlarged and hyper echoic prostatic parenchyma (P) can be seen.

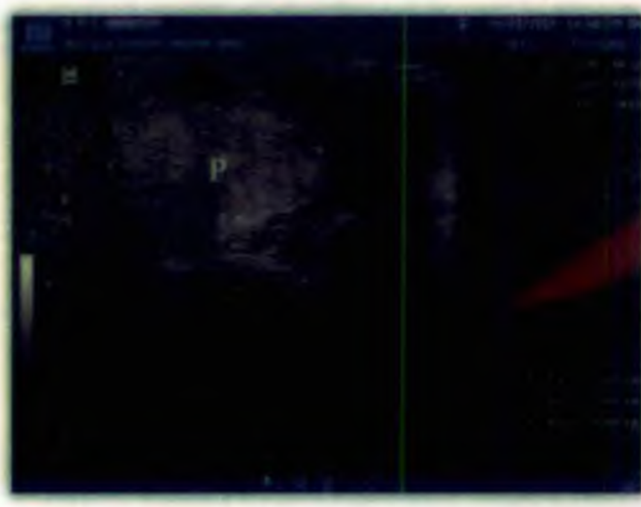

Plate 21. Transrectal ultrasonogram of prostate of an adult German shepherd. The prostatic parenchyma (P) can be seen. Measurement marked 1 indicates width and 2 indicates length

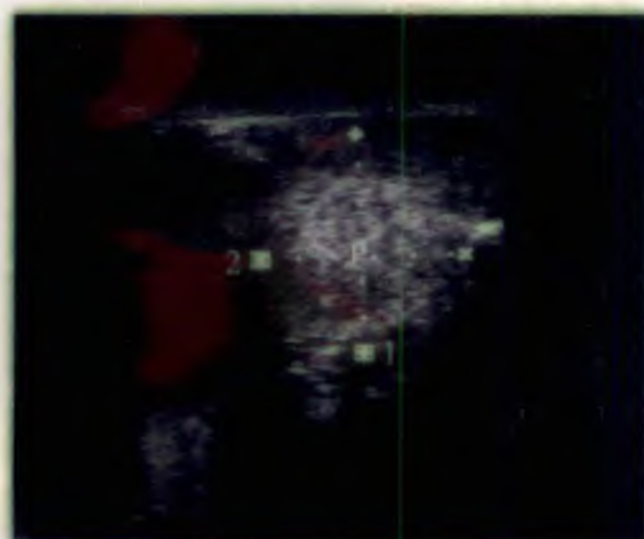

Plate 22. Transrectal ultrasonogram of prostate of an adult Rottweiler. The prostatic parenchyma (P) can be seen. Measurement marked 1 indicates length and 2 indicates width

Discussion

5. DISCUSSION

The study was carried out to evaluate the prostate gland in adult male dogs and to record its biometry using ultrasonography, to correlate various prostatic parameters with breed, age and body weight and to ascertain the prevalence of prostatic disorders among adult dogs.

5.1. DIGITAL PALPATION FINDINGS OF PROSTATE

All the 56 dogs of four different breeds were subjected to digital palpation of the prostate per rectally.

5.1.1. Location of the prostate gland

In the present study, 78.26 per cent of the animals, on digital palpation per rectum, were found to have the prostate in intrapelvic location, which is in agreement with the findings of Burk and Ackerman (1986) and Wallace (2001) who reported that the prostate mostly resided within the pelvic canal. The prostate was positioned partly in the pelvic cavity and partly in the abdominal cavity in 19.57 per cent of the examined animals and in abdominal cavity in the rest 2.17 per cent (Table 1). Similar reports were quoted by Gordon (1961) and Allen *et al.* (1991) who found that the prostate gland of dogs aged more than 10 years were in the abdominal cavity due to progressive hyperplasia with advancing age. Therefore, it appears that an intra-abdominal location of the gland may not necessarily be a sign of prostatic disease unless associated with other clinical signs. In prostatic disease suspected animals, 50 per cent had the prostate gland partly in pelvic cavity and partly in abdominal cavity and the rest 50 per cent had the prostate in abdominal cavity (Table 2). This could be ascribed to the benign hyperplasia, which lead to an enlarged prostate resulting in the change of its position from pelvic to abdominal cavity (Wallace, 2001).

5.1.2. Symmetry of the Prostate Gland

The healthy prostate gland was found to be symmetric in the present study (Table 1). This finding supports the view of Kustritz and Klausner (2000), Johnston *et al.* (2001), Davidson (2003) and Memon (2007) who observed that the prostate of normal male dogs was symmetric on rectal palpation. In prostatic disease suspected animals, 50 per cent had a symmetrical prostate gland and 50 per cent had asymmetrical gland (Table 2). This is in agreement with the findings of Boland *et al.* (2003), White (2005), Freitag *et al.* (2007) and Barsanti (2008) who pointed out that the prostate was symmetric or asymmetric in rectal palpation of dogs with prostatic diseases.

5.1.3. Consistency of the Prostate Gland

The prostate, in the present study, was smooth and firm in 84.78 per cent of normal dogs and soft in 15.22 per cent (Table 1). Similar findings were obtained by Kustritz and Klausner (2000), Johnston *et al.* (2001), Wallace (2001), Davidson (2003), Pacilikova *et al.* (2006) and Memon (2007). In the present study, the soft consistency of the prostate was obtained in the two castrated and one prepubertal male. In diseased dogs, the prostate was hard in 60 per cent, smooth and firm in 20 per cent and soft in 20 per cent dogs (Table 2). This supports the view of Wallace (2001) and Freitag *et al.* (2007) who noticed changes in consistency of the prostate gland in dogs with prostatic disease. It appears that altered consistency of the prostate gland on rectal palpation is a fairly reliable sign of prostatic disease.

5.1.4. Mobility of the Prostate Gland

In all the dogs with an apparently normal prostate gland in the present study, the gland was movable (Table 1). A normal prostate gland was reported to be freely movable when palpated per rectum (Kraweik and Heflin, 1992, Kustritz and Klausner, 2000 and Davidson, 2003). In the present study, in 60 per cent of the prostatic disease affected animals, the prostate gland was not easily movable. The lack of mobility of the prostate gland had also been cited as one of the sign of prostatic disease by Wallace (2001). In 40 per cent of the disease suspected animals the gland is freely movable and it suggests that the absence of mobility alone cannot be taken as a criterion for diagnosing pathologies of the prostate.

5.1.5. Pain on palpation of the Prostate Gland

In the present study, in all normal dogs, the prostate gland did not evince any pain on per rectal digital palpation (Table 1). Pain that the animal exhibits when prostate is palpated has been reported to be an important sign of prostatic cyst or prostatic abscess (Boland *et al.,* 2003., White, 2005., Freitag *et al.*,2007., Parry, 2007., Barsanti, 2008 and Smith, 2008). The presence of pain on digital palpation of the prostate observed in the present study (10 per cent) suggested prostatic affection.

5.2. PROSTATE GLAND EVALUATION BY ULTRASONOGRAPHY

5.2.1. Capsule of the prostate gland

Capsule of the prostate gland was visualized by both transabdominal and transrectal ultrasonography as a uniform, slightly hyperechoic thickening all around the periphery of the prostate gland in 76.09 per cent of the normal dogs examined but was difficult to detect in 23.91 per cent of the dogs (Table 3). The observations of the present study are in agreement with the findings of Green and Homco (1996). Alterations in the contour and thickness of the capsule (Table 4) are observed in 20 per cent of the dogs suspected of having prostatic diseases. This observation is in accordance with Davidson (2003). This suggests that altered echogenecity, regularity and thickness are a definite evidence of prostatic disease.

5.2.2. Parenchyma of the Prostate Gland

The ultrasonographic image of the prostatic parenchyma has been described as uniformly fine medium texture and moderately hyperechoic (Mattoon and Nyland, 1995 and Gradil *et al.*, 2006). In the present study, a moderately hyperechoic prostatic parenchyma was obtained in 95.65 per cent of the normal animals examined. Feeney *et al.* (1987), Mattoon and Nyland (1995) Gradil *et al.* (2006) and Davidson and Baker (2009) observed hypoechoic parenchyma in the prostate of castrated dogs. Similar observations were noticed in castrated animals (4.35 per cent) of the present study. The prostatic parenchyma revealed multiple anechoic/hypoechoic areas in 20 per cent of the prostatic disease suspected dogs, suggestive of prostatic cyst/ abscess and 20 per cent dogs were having normal moderately hyperechoic parenchyma (Table 4). This is in accordance with the observations of Burk and Ackerman (1996), Prufer *et al.* (2000), Miyabayushi (2001), Davidson (2003), White (2005) and Barsanti (2008) who found solitary or multiple hypoechoic or anaechoic lesions in prostatic cyst and abscess ultrasonographically.

5.2.3. Transabdominal ultrasonography of the prostate

5.2.3.1. German shepherd

Menon (2004) recorded the actual prostatic weight during autopsy in German shepherd dogs as 26.31g. In the present study, the mean weight of the prostate gland in German shepherd dogs was observed as 24.33±1.65 g. There is good correlation between age and prostatic volume, age and prostatic weight, body weight and prostatic volume and body weight and prostatic weight ($p<0.01$).

5.2.3.2. Rottweiler

The mean prostatic weight obtained in adult Rottweiler dogs is 24.01±2.66 g. A higher value of 39.70g was reported by Menon (2004). The difference in the mean prostatic weight values could be due to the difference in body weight of the dogs examined, which was 50 kg in the study of Menon (2004) and 35.25 Kg in the present study. There is good correlation between age and prostatic volume, age and prostatic weight, ($p<0.01$). But there was no significant correlation between body weight and prostatic weight and volume.

5.2.3.3. Dachshund

The mean prostatic weight obtained in adult Dachshund dogs of the present study is 10.89±1.0 g. There was highly significant correlation between age and prostatic volume and age and prostatic weight and between body weight and prostatic volume and body weight and prostatic weight. Similar observations were recorded by Menon (2004).

5.2.3.4. Spitz

The mean prostatic weight obtained in adult Spitz dogs in the present study is 8.71±0.2524 g. On the contrary, Menon (2004) recorded the actual prostatic weight in Spitz dogs as 17.93g. There was highly significant correlation between body weight and prostatic volume and prostatic weight ($p<0.01$) and the correlation was significant between age and prostatic volume and prostatic weight ($p<0.05$).

When considering the entire population of normal animals examined (mean age 3.59±0.32 years and mean body weight 19±1.81 kg), the depths in longitudinal and tranverse sections are 2.94±0.01cm and 3.14±0.13 cm respectively. The length in longitudinal section is 3.09±0.12 cm and the width in transverse section is 2.64±0.11 cm. Calculated prostatic volume and weight are 20.23±1.34 cm^3 and 17.66±1.40 g respectively. The findings of the present study are in agreement with those of Kamolpatana *et al.* (2000) who measured the greatest cranio- caudal length (L), and dorso- ventral depth (D) diameters of the prostate as 3.15±0.83 cm and 2.83±0.60cm respectively. But transverse width (W) measured by them (3.15±0.9cm) was slightly greater than that obtained in the present study. The volume obtained in the present study also differed with their findings of 16.77±11.77 cm^3. Ruel *et al.* (1998) obtained slightly higher measurements of prostate of mean length on sagittal section as 3.4±1.1cm and the mean width on transverse images as 3.3±0. The mean calculated volume reported by them was 18.9±15.5cm^3. The measurements of the present study are also lower than the measurements obtained by Atalan *et al.* (1999a). The measurements of prostate obtained by them were 5.4±1.30 cm for length and 4.3±1.11 cm for depth. Variations in the measurements of prostate in the present study are probably due to differences in breed, age and body weight of dogs examined in the studies.

Atalan *et al.* (1999b) measured the prostatic length (L), depth on longitudinal (DL) and transverse sections (DT) and width (W) as 2.9cm, 2.3cm, 2.3cm and 2.5cm respectively and recorded the prostatic volume and weight as 12.3g and 11.2g respectively. The measurements are lower than the measurements obtained in the present study except for the width in transverse section which is similar to the observations of the present study.

Atalan *et al.* (1999c) reported the mean values for prostatic length, prostatic depth in longitudinal and transverse sections and prostatic width as 3.6 cm, 2.8 cm, 2.8 cm and 3.4 cm respectively. The measurements obtained in the present study was similar with these findings but a slight variation in measured width was recorded. However, Rivero *et al.* (2005) obtained higher measurements of depth and length in longitudinal section than those obtained in the present study. Ghadiri *et al.* (2007) obtained similar measurements for length and width and slight variation in depth than those obtained in the present study.

In the present study, there is highly significant correlation between age and prostatic volume and age and prostatic weight and between body weight and prostatic volume and body weight and prostatic weight when all adult intact animals are considered together. The findings of Ruel *et al.* (1998), Atalan *et al.* (1999b) and Atalan *et al.* (1999c) and Gadelha *et al.* (2009) are in agreement with these observations made in present study. The variations in measurements obtained in the present study is probably due to differences in breed, age and body weight.

5.2.3.5. Castrated dogs

The measurements of prostate of castrated dogs (Table 12) were found to be significantly lower when compared to measurements of prostate in adult dogs and the findings are in agreement with those of Basinger *et al.* (1993), Smith (1999), Kustritz and Klausner, (2000) and Davidson and Baker (2009) who found that castration caused reduction in prostatic volume.

5.2.3.6. Pre- pubertal animal

The measurements of prostate of pre-pubertal German shepherd dog (Table 13) was found lower than the measurements of prostate in adult German shepherd dog. Due to paucity of data of measurements of pre- pubertal animals, the data could not be compared.

5.2.3.7. Prostatic disease suspected animals

The measurements of prostate in diseased animals (Table 5) of the present study were found to be much greater than the measurements in healthy adult dogs. Hence it can be inferred that taking measurements of prostate of diseased dogs by ultrasonography will be useful for assessing the status of the gland.

5.2.4. Transrectal ultrasonography of prostate

5.2.4.1. Large breed dogs

The mean prostatic length and width in large breed dogs were 2.94±0.01 cm and 2.43±0.11 cm respectively (Table 15). However, Suzuki *et al.* (1998) obtained higher measurements for the average length and width as 5.97 cm and 4.4 cm.

5.2.4.2. Pre- pubertal German shepherd

The transrectal ultrasonographic measurements of the prostate of the pre pubertal German shepherd (Table 18) in the present study were found to be less than those obtained for adult German shepherd dogs and this suggests that the prostate gland of immature animal will be of lesser size.

5.3. PROSTATIC DISORDERS

In the present study, 10.71 per cent of the total animals examined were found to be having prostatic disorders. The present study revealed that incidence of diseases of the prostate gland is increased as age advanced. Similar observations were reported by Krawiec and Heflin (1992), Green and Homco (1996), Kamolpatana *et al.* (2000) and Paclikova *et al.* (2006). 7.14 per cent of the total animals examined were affected with benign prostatic hyperplasia and all of them were old aged.

5.4. URINALYSIS

In disease suspected and normal healthy dogs, urinalysis could not find major changes except for the presence of few more erythrocytes and squamous epithelial cells in the urine of diseased animals.

5.5. PROSTATIC FLUID CYTOLOGY

The findings in the present study supports the view of Davidson (2003) who found that cytology of the prostatic fluid was normal in dogs with BPH, although hemorrhage may be present.

5.6. CULTURE AND SENSITIVITY OF PROSTATIC FLUID

Culture and sensitivity of the prostatic fluid was negative in all the 20 dogs examined for culture and sensitivity of the prostatic fluid. It was in accordance with the findings of Davidson (2003) that the bacterial cultures were negative or yield low quantitative growth in dogs with BPH. Boland *et al.* (2003) obtained *E. coli* as the most common organism in the bacterial culture of the prostatic fluid of dogs with prostatic abscess. But in the present study, the dog suspected of having prostatic abscess showed no growth in the culture of prostatic fluid. So it is suggested that culture and sensitivity alone should not be relied for the confirmation of prostatic disorders.

5.7. HEMATOLOGICAL STUDIES

5.7.1. Haemogram

The mean erythrocyte count obtained in the normal and diseased animals were 3.33±1.06 and 3.89±1.41 (Table 21) respectively. It was noted that there was no significant difference between the erythrocyte counts of normal and diseased animals.

5.7.2. Leucogram

In one disease suspected dog, there was leucocytosis with a left shift confirming prostatic disease. The findings of the present study is in agreement with the findings of Boland *et al.* (2003), Freitag *et al.* (2007) and Barsanti (2008) who obtained mild to moderate leukocytosis in dogs with prostatic abscess.

5.7.3. Serum biochemistry

The serum alkaline phosphatase and acid phosphatase in disease suspected animals were found unaltered compared to normal adult dogs. However contrary observations were reported by Boland *et al.* (2003), Menon (2004), Freitag *et al.* (2007) and Barsanti (2008).

CONCLUSION

Digital palpation of prostate per rectum is an ancient method used for examination of normal animals and for diagnosing prostatic disorders in dogs. The present study confirms the earlier reports that digital palpation is not a reliable technique to diagnose prostatic disorders due to various reasons. Firstly, the contours of the organ cannot be appreciated clearly in some cases due to interference from other internal organs. Secondly, in old aged and diseased dogs the prostate may usually be extended deep into the abdominal cavity creating difficulty for digital palpation per rectally. Even for an experienced person, the digital palpation of prostate at times may be inconclusive. Considering these aspects, the use of ultrasonography is advisable, as it is more reliable and easy to perform.

Transrectal and transabdominal scanning techniques are found to have its own merits and demerits. Transabdominal method requires more time and preparation of the site like shaving and cleaning and only an experienced technician will be able to perform this technique. Unlike Transabdominal scanning, transrectal scanning offers better visualization of the organ and the measurements can be taken more easily and with confirmation. Hence with respect to better visualization, transrectal scanning is recommended in large breed dogs. Moreover, the better visualization results in easy diagnosis of prostatic disorders. Hence, from the present study, it could be established that transrectal scanning is recommended for the detailed study of prostate gland in large breeds while in the smaller breeds, transabdominal scanning is advised. In small breeds, transrectal scanning using a specialised smaller rectal probe may be useful for ultrasonographic evaluation of prostate.

Summary

6. SUMMARY

The study was carried out to evaluate the prostate gland in adult male dogs and to record its biometry using ultrasonography and to correlate various prostatic parameters with the fertility of the animal.

The data pertaining to the present investigation were generated from the 56 male dogs presented to the out patient unit of University Veterinary Hospitals, Mannuthy and Kokkalai during the period between January 2009 and March 2010.

From among them forty three sexually intact male dogs belonging to four different breeds *viz.* fourteen German Shephered, ten Dachshund, ten Rottweiler and ten Spitz were selected for the study. Their general health condition, age and body weight were assessed. After physical examination of the prostate by digital palpation per rectum, they were subjected to detailed B- mode real- time ultrasound scanning of the prostate gland transrectally (5MHz probe) and transabdominally (7.5MHz probe). The prostate gland of two castrated male dogs, one pre-pubertal dog and ten prostatic disease suspected dogs presented to clinics were also assessed by digital palpation and ultrasonography. The disease suspected animals and ten normal dogs were subjected to urinalysis, prostatic fluid cytology, culture and sensitivity of prostatic fluid, and haematological studies to confirm the disease.

On digital palpation, the prostate gland of all the normal sexually intact dogs was symmetrical, with smooth and firm consistency, movable and painless. In most of them, the gland was pelvic in position. Soft consistency was exhibited in the castrated and pre- pubertal animals. In dogs aged above 10 years, prostate gland was abdominal in location. Most of the dogs suspected to be having prostatic diseases showed hard consistency, les mobility and only one evinced pain on palpation.

Transabdominal ultrasonographic examinations were done in all the dogs. In majority of the animals, there was normal and echogenic capsule and moderately hyper echoic parenchyma.

There was high correlation ($p<0.01$) between prostatic measurements and age and body weight in German shepherd and Dachshund. In Rottweiler dogs, there was highly significant correlation ($p<0.01$) between age and prostatic volume and prostatic weight and the correlation was significant between body weight and prostatic volume and weight. The correlation was highly significant ($p<0.01$) between body weight and prostatic volume and weight in Spitz and significant ($p<0.05$) between age and prostatic volume and prostatic weight. While considering the six diseased animals, the measurements were found greater than those obtained for the normal animals and that suggested prostatic diseases. Four of them were diagnosed as benign prostatic hyperplasia. In remaining two animals, there were multiple anechoic areas in the prostatic parenchyma and were diagnosed as prostatic cyst and abscess respectively. No significant correlations were obtained between age or body weight with prostatic measurements in diseased animals. Two castrated male dogs and one pre pubertal male dog were also examined ultrasonographically and their measurements were found less than the mean prostatic measurements obtained.

From the study, highly significant correlations ($p< 0.01$) were obtained between age and body weight of the animal with prostatic volume and weight when all the normal adult animals were considered together.

Significant difference for prostatic volume and weight was obtained for the four different breeds German shepherd, Rottweiler, and Dachshund and Spitz. It was noticed that the prostatic volume and weight were seen greater in German shepherd followed by Rottweiler, Dachshund and Spitz. Also there was significant difference for the prostatic volume and weight between the diseased and non diseased animals.

Transrectal ultrasonography of prostate in German shepherd dogs and Rottweiler dogs revealed that there was normal and echogenic capsule and moderately hetero echoic parenchyma.

Urinalysis, cytology of prostatic fluid, culture and sensitivity of prostatic fluid and haematology could not establish any direct relationship between prostatic disorders. However, in one case, leucocytosis with left shift was observed suggesting prostatic infection. Prostatic disorders mostly BPH were commonly encountered in older dogs without significant change in clinical and biochemical parameters.

The present study revealed that with the use of real- time B- mode ultrasound transabdominal and transrectal scanning, prostate gland in dogs could be clearly examined. But both transrectal and transabdominal scanning techniques are found to have its own merits and demerits. Transabdominal method requires more time and only an experienced technician will be able to perform this technique. Unlike transabdominal scanning, transrectal scanning offers better visualization of the organ and the measurements can be taken more easily and confirmingly. Transrectal scanning is recommended for the detailed study of prostate gland in large breeds. In small breeds, transrectal scanning using a specialised smaller rectal probe may be useful for ultrasonographic evaluation of prostate. Real-time ultrasound scanning by both transrectal and transabdominal scanning were found to be reliable, safe and accurate for the diagnosis of prostatic disorders.

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ULTRASONOGRAPHIC EVALUATION OF PROSTATE GLAND IN DOGS

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ABSTRACT

Ultrasonographic evaluation of prostate gland of adult male dogs was carried out in the present study to correlate with the fertility of the animal.

Initially digital examination of the prostate gland per rectum was performed in 56 male dogs of four different breeds German shepherd, Rottweiler, Dachshund and Spitz to find the location, symmetry, consistency, mobility and pain on palpation. All the dogs were subjected to transabdominal ultrasonographic evaluation of the prostate. Prostatic measurements were taken in longitudinal and transverse sections. In German shepherd dogs of mean age 4.03years and mean body weight 24.21kg, the mean prostatic volume and weight based on formula calculation were 26.62±1.58 and 24.33±1.65 respectively. In Rottweiler, of 3.35 year and 35.25kg, the calculated mean prostatic volume and weight were 26.32±2.55 and 24.01±2.66 respectively. In Dachshund, the mean age was 3.94 years and the mean body weight was 8.71 kg. Calculated mean prostatic volume and weight were 13.07±0.96 and 10.89±0.10 respectively. In Spitz of mean age 2.95 years and mean body weight 5.46 kg, calculated mean prostatic volume and weight were 11.63±0.24 and 8.71±0.25 respectively. In diseased animals, of mean age 6.67 years and mean body weight 20.35kg, calculated mean prostatic volume and weight were 42.73±8.46 and 41.12±8.82 respectively. The measurements were found greater than measurements of adult animals and that suggested prostatic diseases. Four dogs were found having benign prostatic hyperplasia and one with prostatic cyst and another with prostatic abscess.

Transrectal ultrasonography was done in German shepherd and Rottweilers and for German shepherd, the mean prostatic length obtained was 2.95±0.10cm and

the mean width was 2.44±0.15. For Rottweiler, the mean prostatic length obtained was 2.92±0.15cm and the mean width was 2.42±0.17.

Urine and blood were collected from 10 prostatic disease suspected animals and from 10 apparently healthy animals for detailed clinical investigation. Prostatic fluid was collected from them for cytology and culture and sensitivity tests. In disease suspected and normal healthy dogs, urinalysis could not establish major findings except of the presence of few more erythrocytes and squamous epithelial cells in urine of diseased animals. Culture and sensitivity of urine and prostatic fluid were negative in all the dogs. In 40 per cent of the diseased dogs there were presence of neutrophils and in 30 per cent of them, there were few erythrocytes. The mean erythrocyte count obtained for the normal and disease suspected animals were 3.33±1.06 and 3.89±1.41 respectively. The mean leucocyte count obtained for the normal and diseased dogs were 9485.33±1825.95 and 9854± 1921.02 respectively. There was leucocytosis with left shift in one animal. The mean values for Serum alkaline phosphatase in normal and disease suspected dogs were found as 55.53±11.06 units and 62±9.6 respectively. The mean values for serum acid phosphatase in normal and disease suspected dogs were 4.85±1.96 and 4.74±2.10 respectively. From the study, it was found that prostatic disorders mostly BPH were commonly encountered in older dogs without significant change in clinical and biochemical parameters.

In conclusion, real- time B- mode ultrasound transabdominal and transrectal scanning was found to be reliable, safe and accurate for the examination of prostate gland in dogs. However, in small breeds, transrectal scanning using a specialised smaller rectal probe will be useful for the evaluation of prostate gland.