Supervisor

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2016
الأية

قال تعالى:

(قالوا سبحانك لا علم لنا إلا ما علمتنا انك انت العلم الحكيم)

صدق الله العظيم

سورة البقرة

الأيه 32
Abstract

This is a descriptive study, carried out in order to know the normal measurements (volume and diameters) of prostate gland in North Kurdfan State. The study was done in Elopeid teaching hospital, police hospital, and Elglaa’a, and Wad-elyas health centers, at duration from April-to August, 2016. About 92 patients were randomly selected, aged from 18 years and above, whom have no any symptoms related to prostate pathologies. Trans-abdominal ultrasound scanning by 3.5 MHz probes was performed, and the maximum height, width, and depth of their prostate diameters were obtained, as well as their prostate volumes.

The results of this thesis states that the prostate transverse, AP and longitudinal diameters mean values were (3.53) cm, (2.73) cm, and (2.98) cm respectively, the mean prostate volume obtained from the above parameters was 15.27± 4.7ml.
The study also concludes that, there is an increase in the prostate volume in relation to increase in the patient's age, weight, and body mass indeces by 0.09 ml/year, 0.11 .ml/kg, and 0.3 ml/kg/m² respectively

Moreover the study reveals that the normal prostate has mid-grey level echogenicity, and homogenous in .texture

ملخص البحث

اجريت هذه الدراسة الوصفية من اجل معرفة الحجم الطبيعي لغدة البروستاتا وكذلك قياس الطول والعرض والارتفاع لهذه الغدة لدى الرجال البالغين بولاية شمال كردفان.

اجريت هذه الدراسة بمستشفى الإبيض التعليمي ومستشفى الشرطة، وكذلك بمركز الاليف الصغير، وود الياس الصحي، في الفترة من 17 مارس 2016م. تم اخذ عدد 92 حالة عشوائياً من عمر 18 سنة فما فوق. بعد التاكد من عدم معاناتهم من أي اعراض متعلقة بامراض البروستاتا، وتم فحصهم بالوجتاح فوق الصوتية على منطقة العانة. وبهذه الطريقة تم اخذ الإبعاد القياسية لغدة البروستاتا، وكذلك حجمها.
وجدت الدراسة أن متوسط الابعاد لهذه الغدة هو للطول 2.73 سم والعرض 3.53 سم، أما الارتفاع 2.98 سم، وان متوسط حجم هذه الغدة طبقا لهذه الابعاد هو 15.27 ± 4.7 سم مكعب.

وأثبتت الدراسة كذلك أن حجم غدة البروستاتا يزيد بزيادة بعض العوامل المتعلقة بالشخص كالعمر والوزن وزرن الجسم الكلي للأشخاص بنسب متفاوتة، 0.09 مل لكل سنة، 0.11 مل لكل كيلوجرام، 0.3 مل لكل كيلوجرام مربع الطول.

وأثبتت الدراسة أيضا أن غدة البروستاتا الطبيعية منحنية ودرجة متوسطة الرmadية.

DEDICATION

To the soul of my father and mother
To my lovely wife
(To my sweet heart kids (M, and M

To my brothers Tariq, Nor-Eldin, and Osama

To my colleagues

To the staff of M.sc degree of US in Sudan university

To the all workers, tea makers, library staffs, volunteers, and anyone in this college for their cooperation and help

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My deepest appreciation and sincerest gratitude

To my god for giving me a health to complete this thesis and still giving me more and more

To our staff of M.sc degree for their efforts all through the duration of study
Special thanks and gratefulness to my supervisor Dr. Asmaa Ibrahim Ahmed Alamin for her advices and guidance.

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List of abbreviations

.AJCC..................American Joint Committee on Cancer

.AUA..................American Urological Association

.BPH....................Benign prostatic hyperplasia

.CP/CPP...............Chronic prostatitis/chronic pelvic pain syndrome

.CZ ....................Central zone

.DRE...................Digital per rectum examination

.EDOs...................Ejaculatory duct obstructions

.HIV....................Human immunodeficiency virus

.IPCN..................International Prostatitis Collaborative Network

.LUTS..................Lower urinary tract symptoms

.MHz..................Mega-hertz

.NIDDK.................National Institute of Diabetes and Digestive and Kidney Diseases

.NIH.....................National Institutes of Health

.NKS.....................North Kurd fan State
.NSAIDs.............Non-steroidal anti-inflammatory drugs

.PSA................Prostate specific antigen

.PZ..................Peripheral zone

.TAUS................Tars-abdominal ultrasound

.TNM................Tumor-Node-Metastasis

.TRUS................Trans-rectal ultrasound

.TUUS................Trans-urethral ultrasound

TURED...............Transurethral resection of ejaculatory ducts

.US...............Ultrasound
Chapter one
Chapter one

Introduction

The prostate is a compound tubule-alveolar exocrine gland of the male reproductive system in most mammals. It differs considerably among species anatomically, chemically, and physiologically (Jarble, 2008).

In humans the prostate is an unpaired accessory structure of a male reproductive system that surrounds the urethra (prostatic urethra) in the pelvic cavity (Drake, 2005). It's shaped as an upside-down truncated cone with the base of the gland above related to the urinary bladder, and an apex inferiorly, and four walls, anterior wall, posterior wall, and two inferiolateral walls (Ryan, et.al, 2007).

Structure of the prostate (see page.6) is described traditionally as having five lobes anterior, posterior, median, and two lateral lobes. But more usefully the gland is described based on its internal architecture as having three glandular zones (peripheral, central, and transition) with the non-glandular isthmus anteriorly (Ryan, et.al, 2007).
The normal size of the gland varies according to so many recourses: while it's 20gm in young, more than 40gm is Benign prostatic hypertrophy (Rumack, et.al, 2011), or the mean weight is 11gm ranging from (7-16)gm (Jarble, 2008), it's in some books up to 25gm (Hofer et.al 1999 ) etc.... More over as the prostate volume is calculated with the “oblate spheroid” formula: volume = 0.5236 × (W × AP × L), where W; is the maximal transverse width (right to left), AP; is the anteroposterior plane (anterior midline to rectal surface), and L; is the length (maximal head to foot) (Rumack, et.al, 2011). Again there is also variations in the values of these above mentioned three dimensions; while in some recourses these dimensions were 3.5 x4.5 x 3.5 (Block, 2004), or 4 x 3 x 2 (Sinnatamby, 2004), they were 3 x 3 x 5 in others (Hofer et.al 1999) etc....Prostate volume can be converted to prostatic weight because the specific gravity of the prostate tissue is about 1, thus 1cc (1ml) is equivalent to 1gm (Rumach, et.al, 2011

Estimation of prostatic gland size can be carried out clinically by doing digital per-rectal examination (DRE), or by trans-rectal US (TRUS), both of which are harmful techniques, and many patients get empresses from it, and may refuse them, moreover trans-urethral US (TUUS) is a useful technique but it's invasive and not widely used. So this study will help to respect trans-abdominal US (TAUS) as more practical, more acceptable and accurate
technique. As well as it will helps to put a reference values for normal dimensions and volumes of the prostate in NKS

**Problem of the study :1-2**

The prostate volume measurement is frequently used to diagnose the abnormalities of the gland. But, as mentioned earlier in this chapter the normal size of the gland itself might reveals variations in overlap regions, in addition to that the gland volume is affected by so many factors (age, weight, hormones etc...). Therefore we are in need for estimation of prostate size based on patient's characteristic so as to be as local reference

**Objectives :1-3**

**General objective :1-3-1**

The main purpose of this study is to identify the normal measurement of the prostatic gland in North Kurdfan State peoples

**Specific objectives :1-3-2**
To establish standard measurements of the prostate gland in normal adults by trans-abdominal ultrasound.

To identify the relation between the prostate size and individual's age.

To correlate measurements of the gland with height, weight, and body mass index of the patient.

To identify texture and echo-pattern of normal prostate size.

To test the effect of patient's age, height, weight, and marital status collectively on the prostate gland size.

**Overview of the study :1-4**

This study is concerned with the normal measures of the prostate gland by using trans-abdominal ultrasound, accordingly it falls into five chapters: chapter one is an introduction which includes: brief anatomy, the problem, the objectives of study and the overview. Chapter two includes: detailed background about the anatomy, and sonogram of the gland as well as the literature review. Chapter three deals with the material and methods used to conduct this study. Chapter four illustrates the results using figures and tables. And finally chapter five presents discussion, conclusion, and recommendations of the study followed by references and appendices.
Chapter two
Chapter two

Literature review

Prostate anatomy :2-1

Prostate development :2-1-1

The prostate gland develops as (30-40) individual complex glands, which grow from the urethral epithelium into the surrounding wall of the urethra. Collectively, these glands enlarge the wall of the urethra into what known as the prostate (Drake, 2005). The pelvic part of the endodermic urogenital sinus gives rise to lateral epithelial buds which become the prostatic acini of the peripheral zone. Dorsal out growths from above the level of entry of the mesonephric ducts from the acini of the central zone. The fibromuscular stroma develops from the surrounding mesenchyme (Sinnatamby, 2004)
**Shape and location: 2-1-2**

The prostate is a fibro-muscular gland shaped like an upside-down pyramid, which surrounds the prostatic urethra, extending from the urinary bladder base to the urogenital diaphragm (Bulter, et.al, 2013). The base of the gland is related to the urinary bladder above, an apex inferiorly sitting on the pelvic (urogenital diaphragm), an anterior wall which is separated from the pubic symphysis by the retro-pubic fatty space (of Retzius), a posterior wall related to the rectum, and two infrolateral walls related to the muscles of the pelvic side wall and the anterior part of the levator ani muscles on either side (Ryan, et.al, 2007).

**Structure of prostate: 2-1-3**

According to traditional anatomy, the gland is described as having the following five lobes which are not well demarcated from one another: a muscular anterior lobe (or isthmus) which is anterior to the urethra and is composed mainly of fibro-muscular fibers, and contains little if any glandular tissue, a posterior lobe which is posterior to the urethra and inferior to the insertion of the ejaculatory ducts, a median lobe between the urethra and the ejaculatory ducts, and two lateral lobes, which form the bulk of the gland. The five lobes can only be
differentiated in the fetus up to twenty weeks gestation, in mature gland only three lobes- two lateral lobes and one median- can be distinguished, with the fibro-muscular stroma anteriorly. These lobes can be palpated from the rectum by doing digital per rectum examination (Ryan, et.al, 2007).

The prostate may more usefully be described based on its internal architecture as having three glandular zones (Fig.2-1) with the non-glandular isthmus anteriorly (Ryan, et.al, 2007) so as the following: the central zone comprises approximately 25% of glandular tissue, resistant to diseases, and it’s a midline wedge at the base of the prostate between the peripheral and transitional zones, the peripheral zone comprises approximately 70% of glandular tissue, surrounds the distal urethral segment, separated from the central zone by the surgical capsule, occupies the posterior, lateral, and apical regions of the prostate and its site for most prostatic cancers, and finally the transitional zone comprises 5% of the glandular tissue and periurethral glands, consists of two small glandular areas adjacent to the proximal urethral sphincter, bound caudally by the verumontanum, separated laterally and posteriorly from the outer glands by the surgical capsule, and it’s an area where benign prostatic hypertrophy (BPH) originates (OVEL, 2014).

Histologically, the prostate is a compound tubuloalveolar organ, which, in one plane of section,
presents small to fairly large glandular spaces lined by epithelium. Characteristically, the glands are lined by two layers of cells: a basal layer of low cuboidal epithelium covered by a layer of columnar secretory cells. In many areas, there are small papillary inbuddings of the epithelium. These glands all have a distinct basement membrane and are separated by an abundant fibromuscular stroma (Vinay.et.al, 2005)

The prostate is contained within a sheath or false capsule derived from pelvic fascia. This sheath is composed of smooth muscle, skeletal muscle, and loose connective tissue, penetrated by numerous vessels and nerves (Ryan, et.al, 2007)

**Prostatic urethra :2-1-4**

The prostatic urethra is about 1.25 inches (3cm) long and begins at the neck of the bladder. It passes through the prostate from the base to the apex, where it becomes continuous with the membranous part of the urethra. On its posterior wall is a longitudinal ridge called the urethral crest, on each side of these ridges is a groove called the prostatic sinus, the prostatic glands open into these grooves. On the summit of urethral crest is a depression, the prostatic utricle, which is an analog of the uterus and vagina in females. On the edge of the mouth of the utricle
are the openings of the two ejaculatory ducts (Snell, 1995).
Fig (2-1): shows zonal anatomy of the prostate (Ryan, et.al, 2007)
**Periurethral glands :2-1-5**

Comprise 1% of glandular tissue, also it’s the tissue that lines the prostatic urethra (OVEL, 2014)

**Verumontanum :2-1-6**

It’s the region where the ejaculatory ducts enter the urethra (Fig. 2-2), and divides the urethra into proximal and distal segments (OVEL, 2014)

**Seminal vesicles :2-1-7**

These are paired anatomical structures (Fig. 2-2), lying superior to the prostate, posterior to the bladder, and lateral to the vas deferens. Ducts of the seminal vesicles enter the central zone of the prostate. It stores sperms, and joins the vas deferens to form the ejaculatory ducts (OVEL, 2014)
Fig (2-2): shows the seminal vesicles and vas deferens both end into ejaculatory duct that ends in Verumontanum .(SANDERS and WINTER, 2007)

:Function of the prostate :2-1-8

The function of the prostate is the production of a thin, milky fluid containing citric acid and acid phosphatase. The smooth muscle in the capsule and stroma contract, and the secretion from the many glands is squeezed into the prostatic urethra. The prostatic secretion is alkaline and helps to neutralize the acidity in the vagina (Snell, 1995). Moreover the prostatic secretion
constitutes between 13% and 30% of the volume of semen (Penny, 2011)

**Blood supply of the prostate:**

**Prostaticovesical arteries:**

Arise from the internal iliac arteries. Branches include the prostatic and inferior vesical arteries (OVEL, 2014)

**Capsular arteries:**

They supplies two third of the blood going into the prostate (OVEL, 2014)

**Urethral artery:**

They supplies one third of the blood going into the prostate (OVEL, 2014)

**Venous drainage:**

Via the periprostatic plexus to the internal iliac veins and also to the vertebral venous plexus (prostatic cancer spread to the vertebrae) (Bulter, et.al, 2013)

**Lymphatic drainage of the prostate:**
The lymphatic drainage is to the internal iliac, and obturator lymph nodes (Bulter, et.al, 2013)

**Nerve supply:** 2-1-11

The nerve supply of the prostate is from parasympathetic nerve fibers from pelvic splanchnic nerves (S2-S4) (Ryan, et.al, 2007)

**Prostate sonogram:** 2-2

Now a day's prostate sonography is a frequently used imaging modality to detect its abnormalities. From this point of view here are some informations about the normal appearance, different sonographic techniques, in addition to prostate biopsies.

**Normal appearance:** 2-2-1

In relation to the normal sonographic appearance the prostate gland has a homogeneous structure demonstrating a median-level echo pattern (Fig. 2-3). The peripheral zone (PZ) appears uniform in texture and slightly more echo-genic than the central zone (CZ). A hyper-echoic band (surgical capsule) separates the PZ from CZ. The seminal vesicles appear as hypo-echoic structures superior to the prostate gland. The
verumontanum appears hyper-echoic compared with the parenchyma (VEL, 2014). Patients may have benign calcification and simple-appearing cysts within the prostate as well (Penny, 2011).
Fig. (2-3): TAUS, longitudinal plane (above), and transverse plane (below), shows; normal prostate sonographic appearance (Block, 2004).

**Ultrasound techniques :2-2-2**

**Trans-abdominal approach :2-2-2-1**

Done by using a 3.5 to 5-MHz transducers and a full bladder, the prostate may be identified by angling slightly inferior. Longitudinal and transverse images and measurements may be obtained; however a thorough evaluation of the prostate tissue is not possible. This
approach allows post-void residual within the bladder to be determined by the equation (length x width x height x 0.523) (SANDERS and WINTER, 2007), see technique used on page 21.

**Trans-perineal approach :2-2-2-2**

A perineal approach can be used scanning between the legs posterior to the scrotum, but this is not an ideal way to evaluate the prostate by US. Both transverse and longitudinal images can be obtained and the prostate volume can be calculated; however internal architecture may not be well appreciated. This approach can be used for biopsy if the patient has surgically removed rectum (SANDERS and WINTER, 2007).

**Trans-rectal approach :2-2-2-3**

The most accepted scanning approach when evaluating the prostate. It's done by using 5-9-MHz endocavitary transducers. It's convenient, not invasive, and good image quality. Preparation: needed adequate defication, bladder filling with up to 100cc, condom or protective sheath, careful probe water filling, and the patient should be placed in a left lateral decubitus position (with the knees bent) (SANDERS and WINTER, 2007).
Trans-urethral approach: 2-2-2-4

Require local anesthesia for intra-urethral insertion with rotation. There is good visualization of capsule and intra-capsular spreading tumor. Not appropriate method because of no delineation of periurethral region and more or less invasive (Lee, and Young, 2011).

Ultrasound and prostate biopsy: 2-2-3

Prostate biopsy is taking a sample from the gland to be sent for histopathological study to find out the definite diagnosis. Two methods of prostate biopsy may be used: trans-rectal and trans-perineal. The trans-rectal approach (Fig. 2-4) is more common and less painful but carries a greater risk of infection. The trans-perineal approach is generally only used if the rectum is absent e.g., surgically removed (SANDERS and WINTER, 2007).
Fig. (2-4): shows trans-rectal biopsy procedure (SANDERS and WINTER, 2007).

After either procedure, blood pressure and pulse are taken because hemorrhage is a possible complication. Infection on a delayed basis may occur after a trans-rectal biopsy, but is uncommon. It is expected that blood may be seen within the stool, urine, or sperm after the procedure, for up to 24 hours. Severe bleeding is extremely rare (SANDERS and WINTER, 2007).

**Previous studies:**

This study is conducted to evaluate the prostate weight in Sudanese using ultrasound. The study was carried out in Sinja hospital, in the period from February
2012 –to December 2013. It includes 62 cases aged above 25 years, who were randomly selected from patients visit Sinja hospital for prostate ultrasound. The results of this study show that; the prostate weight increased linearly with the patient age by 0.5gm/year. As well as the prostate weight in respect to patient's weight, and height increased linearly by 0.08gm/kg, and 0.09gm/cm respectively. Also patients with normal prostate weight showed normal echogenicity, and homogeneous texture. More over 78% of single patients has normal prostate weight, while 22% of married patients show normal weights (Elshihawe, 2013).

Another study which was conducted by Yahiya Hassan was carried out to determine the range of volumes of the prostate gland in adult Sudanese males in our local environment using trans-abdominal ultrasound, and to provide acceptable range of normal prostate gland volumes. A randomly selected fifty asymptomatic adult males were recruited and measurements of the maximum length, height and width of their prostate gland were obtained and the volumes were calculated. The results of this thesis were stated as follow: a transverse, AP and longitudinal diameters mean values were (2.68) cm, (3.56) cm, and (3.02) cm respectively, the mean prostate volume obtained from the above parameters was 15.24ml. Also the findings show that prostate volume increases linearly with body weight and age (Abdallah, 2015).
Also there was another thesis which was conducted to measure the normal prostate among Sudanese patients above fifty years old by using trans-abdominal ultrasound. The study was carried out in three hospitals: Bahri hospital, Police hospital, and Alzaiem Alazhari ultrasound clinic, at duration from (June, 2010 –to march, 2011). The study includes 100 cases aged from (50-to 89) years, with different complains. The results of this study shows that the accuracy of ultrasound in prostate measurements and diagnoses is up to 95%, and it's improved due to the use of more effective machines with better resolution. Also the study reveals that a well preparation is a significant factor to obtain good results, and that the ultrasound findings are critically depends on the examiner training and experience. Moreover, the results stated that there is significant proportional relation between patient's age and prostate size, and that there is an inverse relation between the patient's height and the size of the prostate .(Anwar, 2010

Moreover, we have this thesis which was also carried out in order to assess' prostate volume measurement using trans-abdominal ultrasound scanning. In this study, 10 subjects from age of 20 years old to 25 years old were selected to undergo trans-abdominal scans. The subjects were randomly selected with different heights and weights. The subjects were the students whom do not have any bad habits like smoking and drinking. The subject's weights, and heights were measured and their body mass indexes were calculated, as well as their
prostate volumes. The results of this thesis conclude that ultrasound is an easy and safe way to measure the prostate size. In addition to that the results stated that there is an increase in the prostate volume by increasing the weight, or height of the patient. Moreover for the same height increment, the prostate volume was controlled by the weight of the subjects. And finally as this thesis concentrates on body mass indexes, the results find out that the volume of the prostate increases in relation to increase in body size (Skudai, Malaysia, 2012.
Chapter three
Chapter three

Materials & Methods

Materials : 3-1

Subjects : 3-1-1

This is a descriptive study, carried out in order to state the normal measurements of prostate gland in North Kurdfan State. This study was conducted in Eloped city, the capital of (NKS). It was carried out in Eloped teaching hospital, Police hospital, in addition to Elgla'a, and Wadelyas health centers. This study was conducted in duration from April- to August 2016. The population of this study was an adult patient whom referred for abdominal US scans in Eloped city, who were not suffering from any symptoms related to prostate diseases. The sample size of this study was consisted of 92 cases, and they were randomly selected. Any adult patient from (NKS), who referred for abdominal US scans during the duration of the study (April- to August, 2016) was included. Patients who were not resident in (NKS), pediatric age groups, patients who find to have prostatic diseases symptoms, or who are known cases, or detected to have prostatic pathology during US scan, and patients refused to be a candidate of study were all excluded from this study.
**Machines used :3-1-2**

Ultrasound machines: Shimadzu 2200, Japan (2003-2008), Medison Accuvix-XG Korea, (2010-2014), and SonoAce R7, Korea, (2010-2014), all of which has major machine three probes, with full US department facilities, and coupling jell. Also we use a personal computer, Toshiba, Satellite, c660, made in china, 2009. Moreover measurement equipments for heights, and weights of the patient's were used.

**Methods :3-2**

**Technique used :3-2-1**

It was by (TAUS), which was done through the following steps: The patient needs optimal bladder filling if not, more than 40 ounces should be taken by the patient, note that over distended bladder can push the pelvic organs out of view, so you may need to request the patient to void partially (Gilani, 2001). The patient put supine in position, with the legs extended; no breathing technique is recommended (breathing gently) (Gilani, 2001).

Begin with the transducer perpendicular at the body, just superior to the syphysis pubis and angle inferiorly. The
prostate is visualized here. Once the long axis of the prostate is located, angle the transducer inferiorly to scan apex of the prostate until come beyond it. Return to midline just superior to symphysis, with the transducer angled inferiorly-less than before- to locate the long axis of the prostate. When locating the long axis of the prostate, slowly move the transducer towards the patient's right, scan laterally through the prostate until you are just beyond it, going on with the right lateral scan through the pelvic side wall. Return to the midline superior to symphysis with inferior transducer angulations; locate the long axis of prostate. When locating the long axis of the prostate, slowly move the transducer towards the patient's left, scan laterally through the prostate until you are just beyond it. Continue to scan left lateral through the pelvic side wall until beyond it (Gilani, 2001).

Still in sagittal plane, locate the long axis of the prostate; rotate the transducer 90 degree into the transverse seaming plane. Begin with the transducer angle inferiorly, at the midline of the body, just superior to the symphysis pubis. Angle the transducer back into the pelvis; look first for the apex of the prostate. Then scan superiorly through the prostate until you are beyond the base of it (Gilani, 2001)

**Measurements**: 3-2-2
The prostate width and height were taken in a transverse plane, by measuring the maximum right to left diameter and the maximum antero-posterior diameter respectively, while the prostate depth is from a sagittal one, by taking the maximum crainio-caudal diameter. The volume of prostate is calculated by the US machine automatically after measuring the above mentioned three dimensions. The prostate echogenicity, and texture were observed all through the scan.

**Data collection method :3-2-3**

The data of this thesis is collected by using special data collection sheet, which contains eleven variables, divided into two parts: personal data, and sonographic findings. These data were collected in the following ways:

The personal data consists of five variables: patient's index, age, height, weight, and marital status. The patient's age, and marital status were picked up from the patient by direct questions to him (after taking a permission), and this process is done by the doctor in the office, the radiologist, or the technologist. After completing the scan the patient is sent to a nurse so as to complete the other two variables which are the height, and the weight. The nurse do this by using an equipment that measures the weight automatically when the patient
stand on it, but the height is calculated manually by another tool found in the same equipment.

The sonographic finding data includes six variables which are: the height, width, depth, volume, echogenisity, and texture of the prostate gland. These variables are taken also by the radiologist or technologist from the US machine while they were doing the scan, also after the patient has been informed and agree of it.

**Data analysis :3-2-4**

The data was analyzed using Statistical Packaged for Social Studies (SPSS). Using frequency tables, bar graphs, and pie charts, to inter present the variables used in the data collected. Also a correlation tests, scatter, and line plots to find out the definite relationships between the prostate volumes and the other variables under study.

**Data storage :3-2-5**

Data was stored in personal computer, and data sheets were kept safely and responsibly.

**Ethical Issues :3-2-6**

Verbal permissions were taken from the patients before doing scans, and they were informed about the study, and accept it. Also the patients get sure that their
details will not be exposed. Before that verbal permissions were also taken from the head managers of the hospitals, and health centers where the study is conducted.

Chapter four
Chapter four

Results

About 92 cases having neither complain nor pathology related to prostate were selected for this study. The results of this study are presented into tables and figures so as the following:

Figure (4-1A): shows bar graph displaying frequency distribution of prostate width.

Figure (4-1A): shows bar graph displaying frequency distribution of prostate width.
Figure (4-1B): shows bar graph displaying frequency distribution of prostate height.
Figure (4-1C): shows bar graph displaying frequency distribution of prostate depth.
Figure (4-2): line plot shows the linear relationship between patient's age and prostate volumes.

Table (4-1) Model coefficients test expressing the positive linear relationship between the patient's age and prostate volume:

<table>
<thead>
<tr>
<th>Sig</th>
<th>Unstandardized Coefficients</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Constant</td>
</tr>
<tr>
<td>000.</td>
<td>8.35</td>
<td>1.342, 11.214</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Patient's age in</td>
</tr>
<tr>
<td>002.</td>
<td>3.22</td>
<td>Years</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure (4-3): shows scatter plot expressing the linear relationship between the patient's weight and prostate volume.

Table (4-2) Model coefficients test expressing the positive linear relationship between the patient's weight and prostate volume:

<table>
<thead>
<tr>
<th>Sig</th>
<th>t</th>
<th>Std. Error</th>
<th>B</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>009.</td>
<td>2.66</td>
<td>2.82</td>
<td>7.51</td>
<td>(Constant)</td>
</tr>
<tr>
<td>006.</td>
<td>2.79</td>
<td>0.42</td>
<td>117.</td>
<td>Patient's weight in kilograms (kg)</td>
</tr>
</tbody>
</table>
Figure (4-4): shows scatter plot expressing the linear relationship between the patient's height and prostate volume.

Table (4-3) Model coefficients test expressing the positive linear relationship between the patient's height and prostate volume:

<table>
<thead>
<tr>
<th>Sig</th>
<th>t</th>
<th>Unstandardized Coefficients</th>
<th>Std. Error</th>
<th>B</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>1.24</td>
<td></td>
<td>6.518</td>
<td>8.057</td>
<td>(Constant)</td>
</tr>
<tr>
<td>270</td>
<td>1.11</td>
<td></td>
<td>040.044</td>
<td></td>
<td>Patient's height in (cm)</td>
</tr>
</tbody>
</table>
Figure (4-5): shows scatter plot expressing the linear relationship between the patient's body mass (kg/m$^2$) index and prostate volume.

Table (4-4) Model coefficients test expressing the positive linear relationship between the patient's body mass index and prostate volume:

<table>
<thead>
<tr>
<th>Sig</th>
<th>t</th>
<th>Std. Error</th>
<th>B</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>.041.</td>
<td>2.07</td>
<td>3.700</td>
<td>7.669</td>
<td>(Constant) 1</td>
</tr>
<tr>
<td>.041.</td>
<td>2.07</td>
<td>145.</td>
<td>301.</td>
<td>Body Mass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Index</td>
<td></td>
<td>Index</td>
</tr>
</tbody>
</table>


Table (4-5): shows distributions of two groups (Married and Single) with their means and standard deviations calculated:

<table>
<thead>
<tr>
<th>Marital status</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>79</td>
<td>15.5280</td>
<td>4.66278</td>
</tr>
<tr>
<td>Single</td>
<td>13</td>
<td>13.7285</td>
<td>4.79826</td>
</tr>
</tbody>
</table>

Table (4-6): t-test for Equality of Means of two groups:

<table>
<thead>
<tr>
<th>t-test for Equality of Means</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence Interval of the Difference</td>
<td>Std.Error Difference</td>
</tr>
<tr>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>4.58</td>
<td>98.-</td>
</tr>
</tbody>
</table>

Table (4-7): shows Model Summary expressing the effect of age, BMI, and marital status collectively on the prostate volume:

<table>
<thead>
<tr>
<th>Adjusted R Square</th>
<th>R Square</th>
<th>R</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table (4-8): shows the frequency distribution of prostate Echogenicity

<table>
<thead>
<tr>
<th>Prostate echogenicity</th>
<th>Percent</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal echogenicity (mid-grey)</td>
<td>83.7</td>
<td>77</td>
</tr>
<tr>
<td>Hypo-echoic</td>
<td>5.4</td>
<td>5</td>
</tr>
<tr>
<td>Hyper-echoic</td>
<td>10.9</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>92</td>
</tr>
</tbody>
</table>

Figure (4-6): show that most (83.7%) of participants were Normal echogenicity (mid-grey) prostate, (10.9%) Hyper-echoic, while (5.4%) of them appeared Hypo-echoic.

Table (4-9): shows the frequency distribution of prostate texture
Figure (4-7) show that most (95.7%) of participants were Homogeneous prostate texture, while (4.3%) of them were heterogeneous.
Chapter five
Chapter five

Discussion, conclusion, and recommendations

Discussion :5-1

As mentioned earlier, the main purpose of this thesis is to identify the normal measurements of the prostate gland (volume, and dimensions) in NKS peoples using trans-abdominal ultrasound, and to state these measurements in relation to their individual characteristics. So about 92 patients were selected randomly, who have no any complains related to prostate pathology. The results of this thesis find out the following

The prostate transverse, AP and longitudinal diameters were measured and displayed in Fig. (4-1A, B, C), and their mean values were (3.53) cm, (2.73) cm, and (2.98) cm respectively, the mean prostate volume obtained from the above parameters was 15.27± 4.7ml
this mean ranges from (7.86- 24.96) ml. These results agree with (Abdallah, 2015) study, see previous studies. Also the results confirmed that there is positive linear relationship between the age of patients and their prostate volumes fig. (4-2), that's to say when patient's age increases by 1 year the prostate volume also increases by 0.09 ml, see table (4-1). This linear relationship can be stated in the formula: prostate volume (PV) = 0.09 \times \text{Age of patient} + 11.21. This positive relationship is expected because aging is main risk for prostate enlargement BPH as mentioned. And this result agrees with all previous studies.

Moreover there is also another positive linear relationship between the prostate volume and patient's weight Fig. (4-3), that's to say an increase in body weight by 1 kg there should be an increase in prostate volume by 0.11 ml, see table (4-2). This linear relationship can be expressed in the formula: prostate volume (PV) = 0.11 \times \text{Weight of patient} + 7.51. This positive relationship is also expected because an increase in patient weight increases fats concentration in the body, which were the main source of steroid hormones that influence the growth of the prostate gland. Also this result agrees with all previous studies.
Concerning to the relation between the height of the patient and the patient's prostate volume, there is also linear relationship Fig. (4-4), and also it's a positive one. That's to say an increase in body height by 1cm there should be an increase in prostate volume by 0.04 ml, see table (4-3). When this correlation is tested: the coefficients table (4-3) provides that ("Sig." = 0.270 > 0.05) which indicates that there no statistically significant correlation between the patients height and prostate volume. And that this positive relationship occurs by chance. But when comparing this result with those found in the previous studies (page. No 16 - 18), we can accept this positive relationship, based on two out of four thesis confirming it (Elshihawe, 2013 and Skudai, Malaysia, 2012), and one of them said that there is negative relationship (Anwar, 2010), and the last one do not mention .(any correlation (Abdallah, 2015)

Regarding to the body mass index (BMI) and prostate volume, the (BMI) were calculated to all patients by the equation: weight/height squire and we find out that there is a positive linear relationship Fig. (4-5), that's to say an increase in the BMI by 1kg/m$^2$ there should be an increase in prostate volume by 0.3 ml, see table (4-4). This linear relationship can be expressed in the formula: prostate volume (PV) = 0.3 x BMI of patient + 7.67. This positive relationship is also expected because higher BMI simply means heavy weights. This result .agrees with (Skudai, Malaysia, 2012) study

Relating to the effect of marital status on the prostate volume, we find that see table (4-5), the married
patients were 79 persons, and the single ones were 13 persons, and that the mean prostate volumes for both were 15.53± 4.67, and 13.73± 4.8 respectively. And that the difference in means between them is 1.8. We use T-test to test the difference in means between these two mean groups and the results tell us that there is no significantly different because the values in the "Sig. (2-tailed)" Colum see table (4-6) is 0.2 which is more than 0.05. So, we can conclude that marital status has no effect .in the prostate volume among this population

As the humans were not age alone or weight or so, we try to find the effect of the all above mentioned variables (age, BMI, and marital status) collectively on the prostate volume. And we find out that see table (4-7) they are all affect in prostate volume by 14.7%. That means there is another 85% of variables not studied here such as the ethnic group, hormones levels, personal habits e.g., alcohol, and coffee intake, environmental factors and so .on

Studding the echogenicity and texture of the prostate gland the results reveals that, Table (4-8), and Fig. (4-6) shows the echogenicity of the prostate and that 77 patients have normal echo's, 5 patients were hypo-echoic, and 10 of them hyper-echoic. And table (4-9), and Fig. (4-7) shows the texture of the prostate and that 88 patients have homogenous texture, and 4 patients have hetrogenious texture. So we can state that from the
results the normal prostate sonographic appearance is mid-grey level echo's (83.7%), and at the same time homogenous texture (95.7%).

Statistical Methods: the use of comparative analytical method using the SPSS statistical program based descriptive statistics and comparative and relationship hypothesis tests (0.05 sig. level), to demonstrate the differences in (Prostate volume) with respect to (age, height, weight, marital and body mass index). The test was used for (simple linear regression, binary logistic regression, t-tests and correlations) to study the hypothesis which states there are significant differences in Prostate volume.
Conclusion : 5-2

The results of this thesis states that the prostate transverse, AP and longitudinal diameters mean values were (3.53) cm, (2.73) cm, and (2.98) cm respectively, the mean prostate volume obtained from the above parameters was 15.27± 4.7ml.

The study also concludes that, there was linear increase in the prostate volume in relation to increase in the patient's age, weight, height, and body mass indexes by 0.09 ml/year, 0.11 ml/kg, 0.04 ml/cm, and 0.3 ml/kg/m² respectively.

Moreover the normal prostate volume has mid-grey level echogenicity (83.7%), and homogenous in texture.

Also, the study found out that the prostate volume didn't affected by the marital status of the patients among these populations.
Recommendations : 5-3

Trans-abdominal ultrasound is a respectful approach, and should be used confidently in the measurements and evaluation of the prostate gland size and pathologies among Sudanese.

In order to improve the image quality, the patients should be well prepared, and the ultrasound machines should be well adjusted to have better resolution.

As mentioned in the discussion, there is another 85% of factors that might affect the prostate volume were not included here. Therefore, other researches were recommended to cover these factors.

Also, I think that we are in need for assessing the normal prostate measurements in the other different states in our country. So as to have our own local
values, hence we are here in Sudan have different environments and very vary habits.

I notice that some sonologists measure the all three parameters of the prostate (transverse, AP, and length) from one plane, which may produces un accurate volume. Therefore it's better to follow standered protocols to improve our techniques.

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Appendices
<table>
<thead>
<tr>
<th>Text</th>
<th>Ech</th>
<th>Prosta</th>
<th>Prosta</th>
<th>Prosta</th>
<th>MS</th>
<th>Weig</th>
<th>Heig</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>Ech</td>
<td>Prosta</td>
<td>Prosta</td>
<td>Prosta</td>
<td>MS</td>
<td>Weig</td>
<td>Heig</td>
<td>Age</td>
</tr>
<tr>
<td>volum</td>
<td>depth</td>
<td>width</td>
<td>height</td>
<td>volume</td>
<td>depth</td>
<td>width</td>
<td>height</td>
<td>age</td>
</tr>
</tbody>
</table>
Appendix-B

Sudan University of Science and technology
College of Graduated studies
M.Sc of Diagnostic ultrasound
Measurement of normal Prostatic gland in Sudanese people
Data Collection sheet

....../....../.....:Date
Patient data

-Patient's ID

-Patient's age: 

-Patient's marital status

-Patient's height:

-Patient's weight:

Sonographic findings

-Prostatic length

-Prostatic width

-Prostatic depth

-Prostatic weight

-Prostatic echogenicity

-Prostate texture