Chapter One

1.1 Introduction:

Prostate is a compound tubuloalveolar exocrine gland of the male reproductive system. The function of prostate is to secrete slightly alkaline fluid, which has the characteristic of milky or white in appearance. The secretion usually constitutes 20% to 30% of the volume of the semen along with spermatozoa and seminal vesicle fluid. In medical practice, most of the prostate abnormalities are diagnosed by measuring their volume . Normally, the prostate volume range between 0.250ml at birth to 10.000 ml sized at puberty. After puberty, the prostate volume will continuously grow as the age increase for most of the male's life. A healthy human male prostate has the volume of 10.000 ml. The prostate is located above the base of the penic and below the urinary bladder and backs into the front wall of rectum.

The prostate secretes some of the fluid for semen, stops urination during ejaculation, and enhances sexual pleasureable sensations (Patel and Jones, 2009)

Reliable and precise ultrasonography measurement of prostate volume (PV) is very important for the management of prostate diseases. It is crucial not only for diagnosis purposes but also in planning non-invasive treatments of prostate cancer and follow ups (Sun and Seung, 2008)

In clinical setting, measurement of prostate volume via ultrasonography is conducted in several ways, namely transperineal (TPUS) , transrectal (TRUS) and transabdominal (TAUS) .

Historically, transperineal route was the first one used to reach and image prostate , as it was used to guide biopsy procedure since 1950.

In transperineal ultrasound imaging, ultrasound transducer is placed in the perineal area while the patient lies down in supine lithotomy position.

Due to the position of the transducer, images of bladder and prostate are allowed to be reached since anatomically, both structures fall within the transducer's field of view . However, the sensitivity of TPUS in imaging clear prostate is very limited as report from previous studies showed that TPUS done by experienced sonographer can only be able to detect a very low percentage of known cancer. This is due to its restriction in visualizing abnormalities of the prostate, particularly at hyperechoic area (Rajesh and Martha , 1999).

Transrectal ultrasound examination is a common outpatient procedure involving digital ultrasound for the assessment of prostate via rectum [13]. The examination is performed by placing a small and lubricated intracavity probe of high frequency into the rectum either for imaging or guiding biopsy. Nowadays, transrectal guided biopsy is a gold standard for diagnosis of prostate cancer as the combination of prostate biopsy and prostate ultrasonography yield the best diagnostic outcome of prostate cancer. The transrectal method provides a clear image of organs in the pelvis. Normally, transrectal ultrasound is used for the evaluation of the prostate gland with elevated prostate specific antigen (PSA) or prostatic nodules on digital rectal examination. Although this method is reported to give high accuracy, its usage requires high patient tolerance as it involves insertion of the intracavity probe into the rectum. Another issues concerning the usage of transrectal ultrasound is the intraobserver variations. Depending on the sonographers's knowledge and experience, values measured by each sonographer are different resulting in low reproducibility of clinical result and causes clinical decision making to be complicated. Hence, transabdominal method has become a standard clinical tool for a rapid, simple and noninvasive screening of the prostate (Scattoni, et al., 2007).

.

Transabdominal ultrasound uses 3-5MHz transducer through a partially or fully filled urinary bladder with caudal angulation to send the ultrasound beam under the pubic arch and permit global volume measurements of the prostate.

In this method, the transmitted and reflected ultrasound waves visualize the organs through the abdominal wall. The advantage of transabdominal ultrasound is that procedure can be performed quickly and non-invasively (Walz, et al., 2006)

Measurements of prostate volume have become very important clinically since its association with different diseases and variables of malignancy. The American Cancer society found that prostate cancer is one of the most common cancers in men (Marx and Karenberg, 2009) and is getting serious attention from the world as it has become a significant cause of death every year.

A few researches reported that prostate volume highly contributes in diagnosis of prostate cancer. These studies show that large prostate volume has an increased risk of malignancy (Evelyn , 2010)

1.2. Problem of the study :

.Prostate diseases now widespread in Sudan so this study try to assess the prostate volume, in healthy subjects by using ultrasound.

1.3.Objectives’:

1.3.1 main objective

To Measure the Normal Prostate Volume in Adult Sudanese's Subjects Using-Ultrasound

1.3.2 Specific objectives

This study was carried out:

-To determine the range of volumes of the prostate gland in adult males in local environment using supra-pubic ultrasonography,

- To provide acceptable range of normal prostate gland dimensions.

1.4. Overview of the study:

Chapter one :

Deal with introduction

Chapter two:

Included literature review

Chapter three:

deal with the material & methods

Chapter four:

Included result presentation

Chapter five:

Deal with Discussion, conclusion and Recommendation

Chapter two

2- Theoretical background

2-1 Anatomy

The **prostate** (from Greek προστάτης, *prostates*, literally "one who stands before", "protector", "guardian" is a compound tubuloalveolar exocrine gland of the male reproductive system in most mammals. It differs considerably among species anatomically, chemically, and physiologically. A healthy human prostate is classically said to be slightly larger than a walnut. The mean weight of the normal prostate in adult males is about 11 grams, usually ranging between 7 and 16 grams. Leissner and Tisell (1979). It surrounds the urethra just below the urinary bladder and can be felt during a rectal exam.

The secretory epithelium is mainly pseudostratified, comprising tall columnar cells and basal cells which are supported by a fibroelastic stroma containing randomly orientated smooth muscle bundles. The epithelium is highly variable and areas of low cuboidal or squamous epithelium are also present, with transitional epithelium in the distal regions of the longer ducts. Within the prostate, the urethra coming from the bladder is called the prostatic urethra and merges with the two ejaculatory ducts.

The prostate can be divided in two ways: by zone, or by lobe. It does not have a capsule, rather an integral fibromuscular band surrounds it. It is sheathed in the muscles of the pelvic floor, which contract during the ejaculatory process.

The "zone" classification is more often used in pathology. The idea of "zones" was first proposed by McNeal in 1968. McNeal found that the relatively homogeneous cut surface of an adult prostate in no way resembled "lobes" and thus led to the description of "zones". Myers, Robert P (2000).

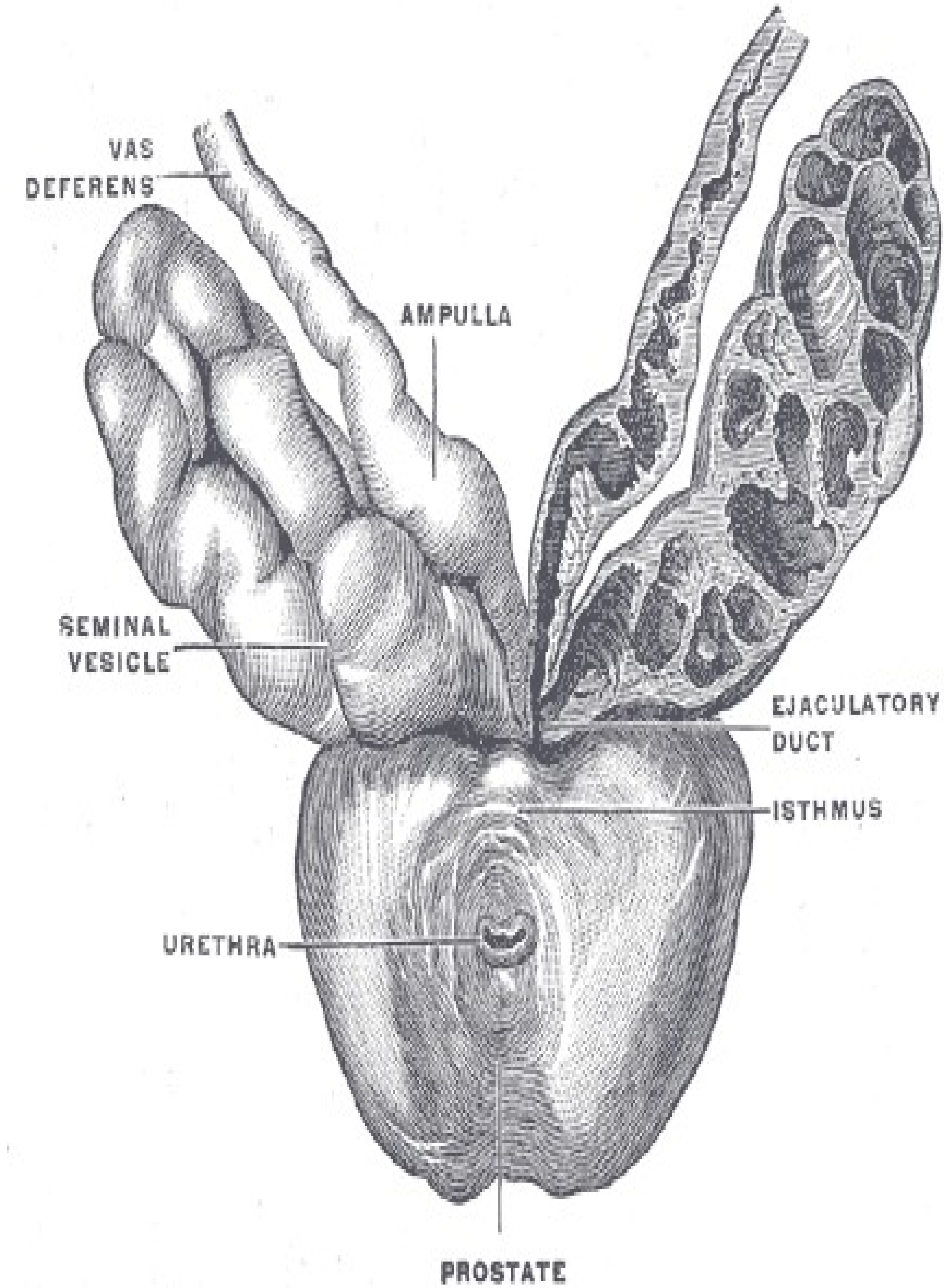

Figure 2-1 **Prostate with seminal vesicles and seminal ducts, viewed from in front and above.**

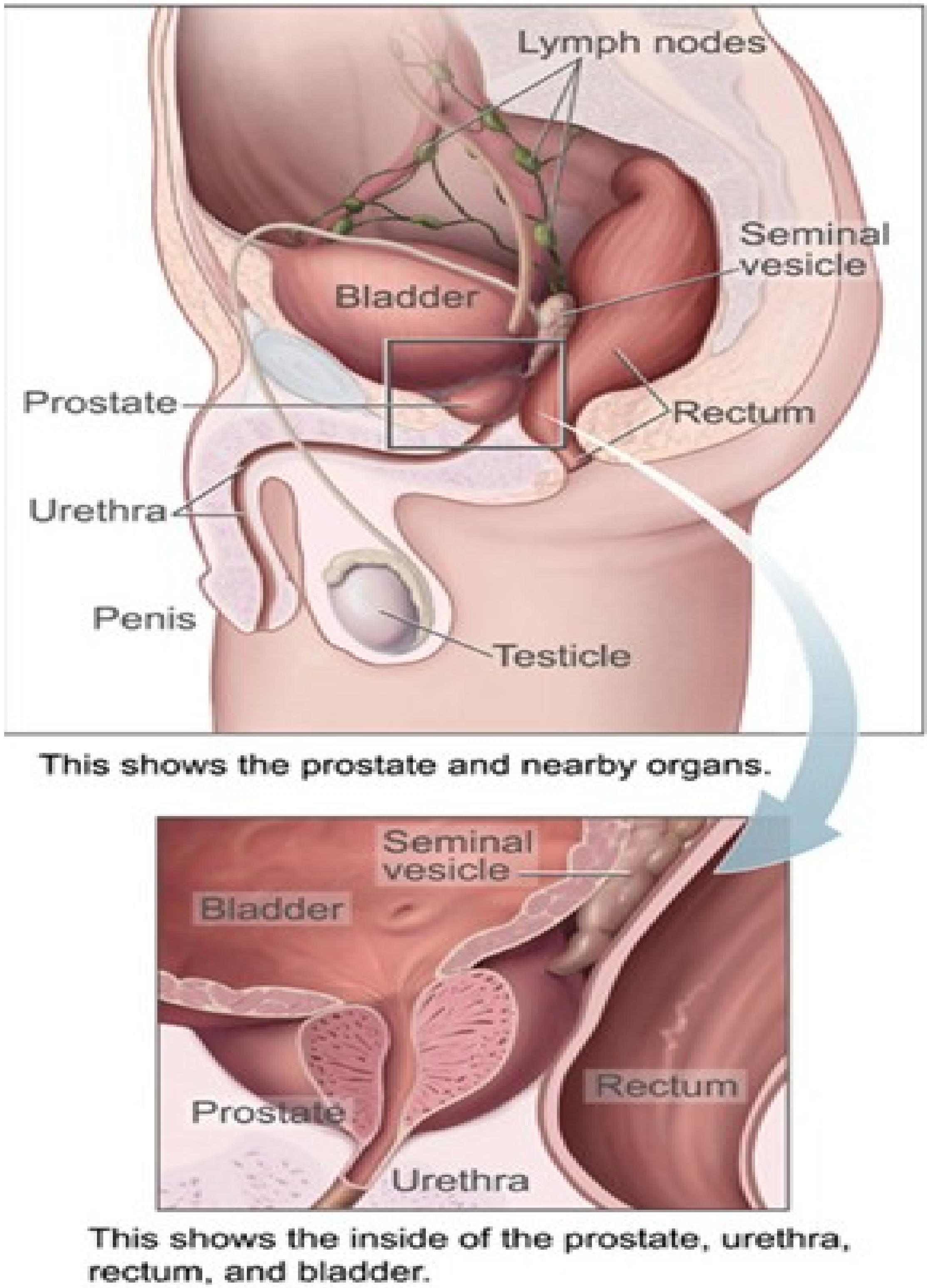

Figure (2.2) shows prostate from inside and nearby organs.

2-2 Physiology

The function of the prostate is to secrete a slightly alkaline fluid, milky or white in appearance,[9] that usually constitutes 50–75% of the volume of the semen along with spermatozoa and seminal vesicle fluid. Semen is made alkaline overall with the secretions from the other contributing glands, including, at least, the seminal vesicle fluid. The alkalinity of semen helps neutralize the acidity of the vaginal tract, prolonging the lifespan of sperm. The alkalinization of semen is primarily accomplished through secretion from the seminal vesicles. The prostatic fluid is expelled in the first ejaculate fractions, together with most of the spermatozoa. In comparison with the few spermatozoa expelled together with mainly seminal vesicular fluid, those expelled in prostatic fluid have better motility, longer survival and better protection of the genetic material. The prostate also contains some smooth muscles that help expel semen during ejaculation.

2-2-1 Male sexual response

During male ejaculation, sperm is transmitted from the ductus deferens into the male urethra via the ejaculatory ducts, which lie within the prostate gland. It is possible for men to achieve orgasm solely through stimulation of the prostate gland, such as prostate massage or receptive anal intercourse Komisaruk, et al (2009).

2-2-2 Secretions

Prostatic secretions vary among species. They are generally composed of simple sugars and are often slightly acidic. In human prostatic secretions, the protein content is less than 1% and includes proteolytic enzymes, prostatic acid phosphatase, beta-microseminoprotein, and prostate-specific antigen. The secretions also contain zinc with a concentration 500–1,000 times the concentration in blood.

2-2-3 Development

The prostatic part of the urethra develops from the *pelvic* (middle) part of the urogenital sinus (endodermal origin). Endodermal outgrowths arise from the prostatic part of the urethra and grow into the surrounding mesenchyme. The glandular epithelium of the prostate differentiates from these endodermal cells, and the associated mesenchyme differentiates into the dense stroma and the smooth muscle of the prostate. Moore et al (2008) .The prostate glands represent the modified wall of the proximal portion of the male urethra and arises by the 9th week of embryonic life in the development of the reproductive system. Condensation of mesenchyme, urethra and Wolffian ducts gives rise to the adult prostate gland, a composite organ made up of several glandular and non-glandular components tightly fused.

2-2-4 Regulation

To function properly, the prostate needs male hormones (testosterones), which are responsible for male sex characteristics. The main male hormone is testosterone, which is produced mainly by the testicles. Some male hormones are produced in small amounts by the adrenal glands. However, it is dihydrotestosterone that regulates the prostate.

2-3 Prostate disorders

2-3 -1 Prostatitis

Prostatitis is inflammation of the prostate gland. There are primarily four different forms of prostatitis, each with different causes and outcomes.

Two relatively uncommon forms, acute prostatitis and chronic bacterial prostatitis, are treated with antibiotics (category I and II, respectively).Chronic non-bacterial prostatitis or male chronic pelvic pain syndrome (category III), which comprises about 95% of prostatitis diagnoses, is treated by a large variety of modalities including alphablockers, phytotherapy, physicaltherapy, psychotherapy,antihistamines, anxiolytics, nerve adulators, surgery, and more. More recently,a combination of trigger point and psychological therapy has proved effective for category III prostatitis as well. Anderson et al (2006). Category IV prostatitis, relatively uncommon in the general population, is a type of leukocytosis

2-3 -2 **Benign Prostatic Hyperplasia (BPH).**

Benign prostatic hyperplasia (BPH) occurs in older men; the prostate often enlarges to the point where urination becomes difficult. Symptoms include needing to urinate often (frequency) or taking a while to get started (hesitancy). If the prostate grows too large, it may constrict the urethra and impede the flow of urine, making urination difficult and painful and, in extreme cases, completely impossible.

BPH can be treated with medication, a minimally invasive procedure or, in extreme cases, surgery that removes the prostate. Minimally invasive procedures include transurethral needle ablation of the prostate (TUNA) and transurethral microwave thermotherapy (TUMT). These outpatient procedures may be followed by the insertion of a temporary prostatic stent, to allow normal voluntary urination, without exacerbating irritative symptoms.

The surgery most often used in such cases is called transurethral resection of the prostate (TURP or TUR). In TURP, an instrument is inserted through the urethra to remove prostate tissue that is pressing against the upper part of the urethra and restricting the flow of urine. TURP results in the removal of mostly transitional zone tissue in a patient with BPH. Older men often have corpora amylacea Kristal *et al.* (2008). (amyloid), dense accumulations of calcified proteinaceous material, in the ducts of their prostates. The corpora amylacea may obstruct the lumens of the prostatic ducts, and may underlie some cases of BPH.

Urinary frequency due to bladder spasm, common in older men, may be confused with prostatic hyperplasia. Statistical observations suggest that a diet low in fat and red meat and high in protein and vegetables, as well as regular alcohol consumption, could protect against BPH.

2-3 -3 **Prostate cancer**

Prostate cancer is one of the most common cancers affecting older men in developed countries and a significant cause of death for elderly men (estimated by some specialists at 3%. Despite this, the American Cancer Society's position regarding early detection is "Research has not yet proven that the potential benefits of testing outweigh the harms of testing and treatment" and that they believe "that men should not be tested without learning about what we know and don't know about the risks and possible benefits of testing and treatment. Starting at age 50 (age 45 if you are of Black race or if your father or brother acquired prostate cancer before age 65), talk to your doctor about the pros and cons of testing so you can decide if testing is the right choice for you".(Morgan et al 2011) If checks are performed, they can be in the form of a physical rectal exam, measurement of prostate specific antigen (PSA) level in the blood, or checking for the presence of the protein Engrailed-2 (EN2) in the urine.

Co-researchers Hardev Pandha and Richard Morgan published their findings regarding checking for EN2 in urine in the 1 March 2011 issue of the journal Clinical Cancer Research. A laboratory test currently identifies EN2 in urine, and a home test kit is envisioned similar to a home pregnancy test strip. According to Morgan, "We are preparing several large studies in the UK and in the US and although the EN2 test is not yet available, several companies have expressed interest in taking it forward."

The value of prostatic sonography has dramatically increased in the past three decades. Transrectal ultrasound (TRUS) imaging is currently an integral part of prostate cancer diagnosis and treatment procedures, providing high-resolution anatomical detail of the prostate region.

2-4- Prostate Volume Ultrasonography Measurements

In clinical setting, measurement of prostate volume via ultrasonography is conducted in several ways namely transperineal (TPUS), transrectal (TRUS) and transabdominal (TAUS) . Historically, transperineal route was the first one used to reach and image prostate as it was used to guide biopsy procedure since 1950. In transperineal ultrasound imaging, ultrasound transducer is placed in the perineal area while the patient lies down in supine lithotomy position. Due to the position of the transducer, images of bladder and prostate are allowed to be reached since anatomically, both structures fall within the transducer's field of view .However, the sensitivity of TPUS in imaging clear prostate is very limited as report from previous studies showed that TPUS done by experienced sonographer can only be able to detect a very low percentage of known cancer. This is due to its restriction in visualizing abnormalities of the prostate, particularly at hyperechoic area Rajesh and Martha.1999 Transrectal ultrasound examination is a common outpatient procedure involving digital ultrasound for the assessment of prostate via rectum. The examination is performed by placing a small and lubricated intracavity probe of 7.5MHz into the rectum either for imaging or guiding biopsy .

Nowadays, transrectal guided biopsy is a gold standard for diagnosis of prostate cancer as the combination of prostate biopsy and prostate ultrasonography yield the best diagnostic outcome of prostate cancer. The transrectal method provides a clear image of organs in the pelvis. Normally, transrectal ultrasound is used for the evaluation of the prostate gland with elevated prostate specific antigen (PSA) or prostatic nodules on digital rectal examination .Although this method is reported to give high accuracy, its usage requires high patient tolerance as it involves insertion of the intracavity probe into the rectum. Another issues concerning the usage of transrectal ultrasound is the intraobserver variations. Depending on the sonographers's knowledge and experience, values measured by each sonographer are different resulting in low reproducibility of clinical result and causes clinical decision making to be complicated. Hence, transabdominal method has become a standard clinical tool for a rapid, simple and noninvasive screening of the prostate.

Transabdominal ultrasound uses 3-5MHz transducer through a partially or fully filled urinary bladder with caudal angulation to send the ultrasound beam under the pubic arch and permit global volume measurements of the prostate .

In this method, the transmitted and reflected ultrasound waves visualize the organs through the abdominal wall. The advantage of transabdominal ultrasound is the procedure can be performed quickly, and non-invasively Walz, et al, 2006.

2-4-1 Importance of Prostate Volume measurements

Measurements of prostate volume have become very important clinically since its association with different diseases and variables of malignancy. The American Cancer society found that prostate cancer is one of the most common cancers in men and is getting serious attention from the world as it has become a significant cause of death every year.

A few researches reported that prostate volume highly contributes in diagnosis of prostate cancer. These studies show that large prostate volume has an increased risk of malignancy Evelyn , 2010

However, another studies with the same scope concluded that prostate gland harbouring carcinoma were significantly smaller than in men without malignancy This include the most recent study on relationship between prostate volume and some histological criteria of malignancy which concluded that small prostate volume having weight smaller than or equal to 20g harbors tumors of great malignancy while those of large volume with weight greater than 90g is more often harbors unifocal and low grade tumors .

As the critical size related to malignancy is stated concisely in this study (_20g and _90g), it is yet to determine the range of normal volume of prostate since its volume is influenced by so many factors including adiposity , ages ,body size and frequency of sexual activity . Other than that,previous report also shows that prostate volume may also be influenced by ethnicity and migration .Therefore, this presents study will investigate the correlation between body weight, height and age to healthy multiethnic sudanese population as an early baseline study .

2-4-2 Prostate Ultrasonographic Scanning Protocols

Overall ultrasonographic scanning was conducted by using different ultrasound machines . The devices were set to a 2D mode and a convex probe with frequency of 4- 3.5 MHz was used for imaging from longitudinal plane as shown in Fig. (2.3) Measurements were conducted under general setting of the ultrasound machine.

The subjects were first instructed to fully fill their urinary bladder by consuming water 30 minutes before the measurement. This was to ensure that the anatomy of prostate could be well-imaged and observed.

The measurement was conducted by placing the transducer on the superficial of the abdominal area with subjects laid in supine position during scanning.

Fig. (2.3) Toshiba Aplio MX model ultrasound.

Fig. (2.4). Transabdominal scanning of prostate from longitudinal plane

2-4-3 Image Processing

Segmentation of the edge of prostate gland will provide better accuracy for volume measurement. Overall image processing works were conducted in Matlab, Mathwork Inc., Natick, Massachusetts, USA. The original images contain unwanted data and noises. Hence, image processing was started by cropping, to isolate the region of interest from its background that contains unwanted information. Then, the cropped image was filtered by using median filter to remove noises and enhanced the image contrast in the region of interest. Later, the image format was converted from its original matrix scale to gray scale and finally to black and white scale to ease the edge detection process of the prostate image. Ultrasonography is firmly established diagnostic tool in prostatic imaging. Recent development in US technology has led to significant improvements in image quality, consistency and resolution. Additionally, dynamic scanners, color flow imaging and real time imaging have allowed appreciation of blood flow, reduced examination time and improved quality of the image.

These advances combined with the portability, relative low cost and lack of risks of iodinated contrast media and irradiation have made US one of the most useful modality in evaluation of the prostate. Many approaches can be used to image the prostate as trans-abdominal, trans-urethral, trans-perineal and transrectal US. The common two approaches are transabdominal and transrectal ultrasound.

Transabdominal US of the prostate is nearly universally available and provides excellent anatomic information using the urine-filled bladder as an acoustic window. Prostate size, weight, shape and intravesical extent can be determined. Caudal angulation of the transducer to accommodate the public bone is often required. The normal prostate appears as a homogenous, round or ovoid structure with uniform low level echoes. The intraglandular zonal anatomy can not be visualized (Fig. (2.5). The relation between the prostate, bladder and seminal vesicles can be demonstrated (Abu-Yosef & Noryana 1982).

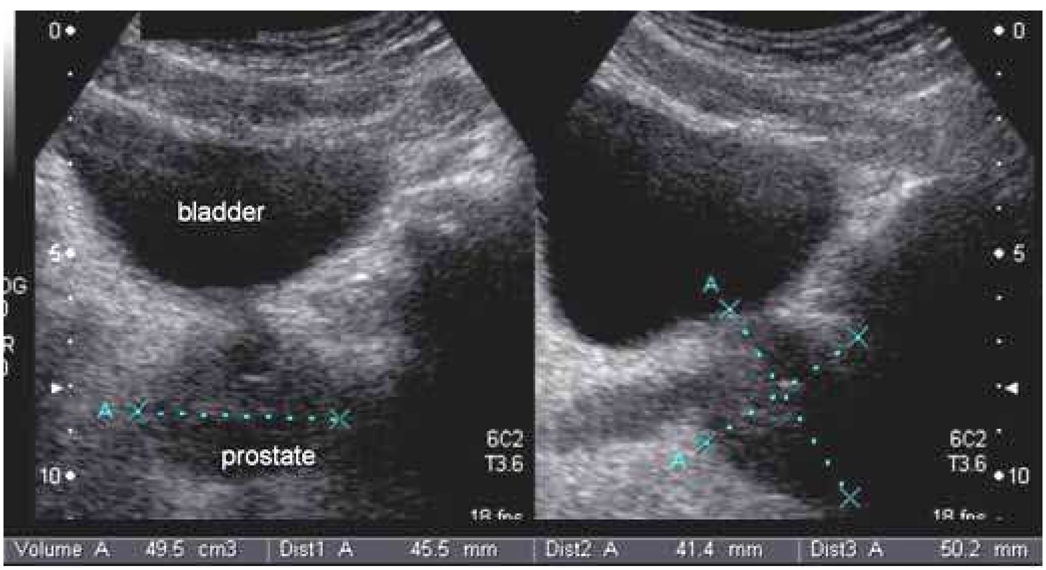

Fig. (2.5). Transabdonal US of a moderately enlarged prostate in axial and sagittal planes

In 1963, Takahashi and Ouchi were the first to describe the use of TRUS to evaluate the prostate. The first clinically applicable images of the prostate obtained with TRUS were described in 1967 by Watanabe et al, they used a 3.5 MHz transducer, which at that time was considered to be state of the art, to obtain images that were clinically meaningful. As US technology has become more refined, the use of TRUS in the evaluation of prostatic disease has increased. By the mid 1980s.TRUS had become a standard diagnostic instrument of the urologists and radiologists. Most investigators today prefer equipment using hand-held transducers which are available in frequencies ranging from 3.5 MHz up to 10 MHz with the optimum frequency being around 7.0 MHz. Transrectal probes are available in different sizes and shapes with diameters ranging from 1.2 to 2 cm.

2-4-4 Sonographic anatomy of the normal prostate

Transrectal US of the prostate has revolutionized our ability to examine this organ. It provides excellent visualization of the prostate in the axial and sagittal planes.

In the axial plane, scanning usually begins at a level just above the seminal vesicles and by sequential withdrawing of the transducer in a caudal direction, the base, mid gland and the apex is visualized (Fig. 2.6).

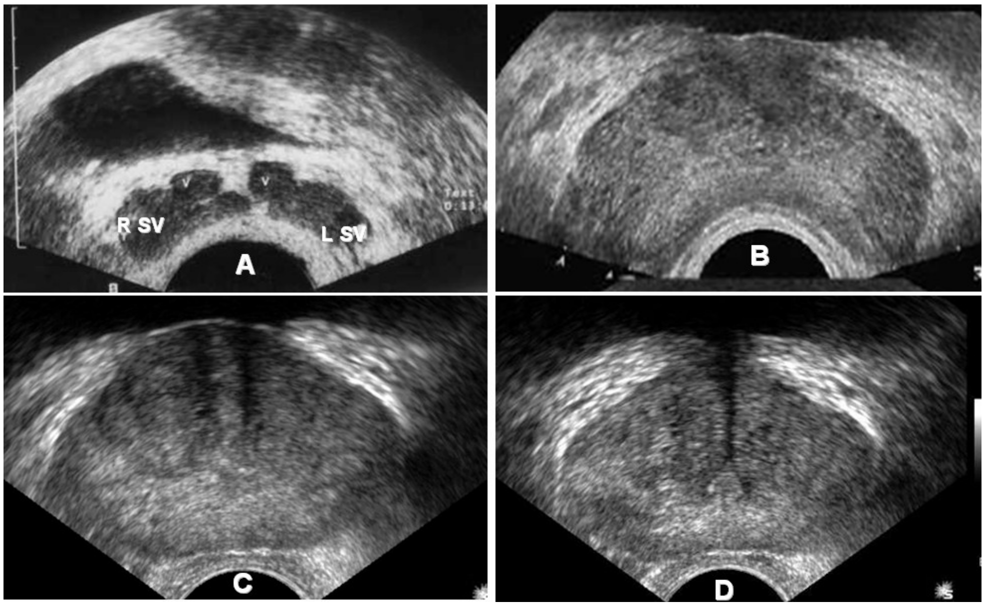

Fig. 2.6. TRUS axial images. (A) the level of distal seminal tract; showing seminal vesicle (SV) and vasl ampulla (V), (B) level of prostate base, (C) level of mid gland and (D) level of vera

When scanning the most cephalad areas, the vas deferens will be visualized. They will appear as bilateral round cystic structures. Then the seminal vesicles will come into view as the vas deferens joins with them superior to the prostate. They usually appear as bow-tie configuration, but they may be rounded, lobulated or flattened.

At the level of the base of the prostate, the prostate appears as a symmetrical crescentshaped with triangular postero-lateral margin. The normal prostate will appear hyperechoic to the sminal vesicles and will have a homogenous echopattern. The CZ and TZ cannot be individually distinguished by their echogenicity. However the PZ appears more echogenic with homogenous echotexture. At the level of mid gland, the prostate becomes ovoid in shape. The anterior fibromuscular tissue is seem and has an echogenicity equal to or less than that of the glandular areas. The hypoechoic periurethral glandular tissue is demonstrated as hypoechoic area in the midline. Posterior and lateral to the PUG tissue, the PZ appears more echogenic and homogenous. The apex of the prostate appears more rounded. The obturator internus and levator anu muscles appear as hyperechoic structures lateral to the prostate apex. The prostate is surrounded by hyperegenic layer comprising the prostatic capsule and surrounding fat and fascia.

The normal prostatic urethra is rarely visualized. The advantages of axial scanning include visualization of the left-right symmetry and echotexture,visualization of the anterior lateral portions of the PZ in a single view and assessment the lateral extracapsular spread of carcinoma (Rifkin, 1997).

In the sagittal plane scanning starts in the midline where the entire prostate can be visualized in one image. The seminal vesicle will be superior and posterior to the base of the prostate, and the vas deferens will be seen anterior to the seminal vesicles. The seminal vesicles will be less echogenic than the prostate and will appear rounded in shape. In the midline sagittal plane, the hypoechoic periurethral tissue will be seen and may be difficult to differentiate form the anterior fibromuscular stroma. The rest of the prostate will be homogenous in echogenicity with the PZ slightly more echogenic than the CZ and TZ (fig. 2.7).

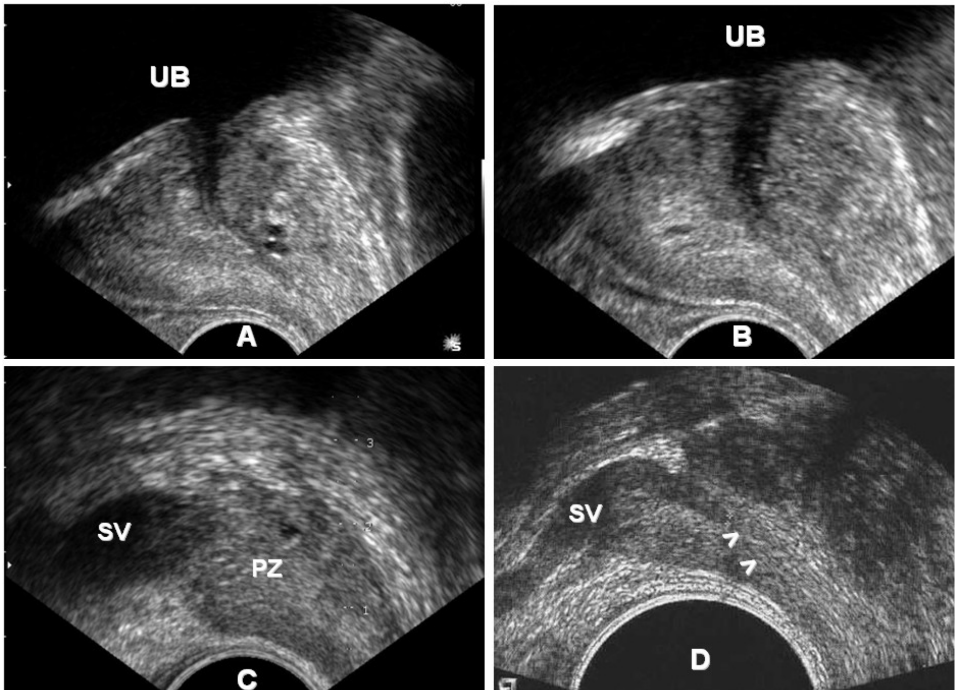

Fig. 2.7. TRUS sagittal images; (A) in midline; (B) in paramedical region; (C) peripheral part of the gland which is formed mainly of peripheral zone (PZ) and above it the body of seminal vesicle (SV) and (D) shows the confluence of vas and seminal vesicle (SV) to form the ejaculatory duct (arrowhead)

By tilting the transducer slightly to the right or the left of midline, the lateral aspects of the prostate and seminal vesicles will be visualized. The lateral aspects of the prostate are normally more rounded and homogenous in ehcogenicity. The ejaculatory ducts can be identified as hypoechoic lines structures between two parallel echogenic lines as the course from the seminal vesicles through the CZ into prostatic urethra. The advantages of sagittal scanning include evaluation of the base and apex of the prostate in a single view, accurate measurement of the cranio-caudal diameter of the prostate or of a lesion within the prostate and better demonstration of the prostatic urethra and ejaculatory ducts ((Rifkin, 1997)

Estimation of prostate volume may be useful in a variety of clinical settings. In cases of BPH, most urologists prefer to perform transurethral resections for glands under 60 grams, while open prostatectomy is preferred for glands over 60 grams (Narayan & Foster 1991). Other potential users include the comparison of the prostate volume with levels of PSA for early detection of the prostatic cancer. PSA density is an index calculated by dividing PSA by the volume of the prostate measured by TRUS. In absence of cancer, prostatic volume is directly proportional to circulating serum PSA (Benson et al., 1992). Benign prostatic hyperplasia is associated with, on average, only 0.26 ng/ mL PSA per gram of tissue, whereas cancer results in a density 10-fold higher (Hammerer et al., 1995). Any PSA value greater than that predicted by gland volume should raise a suspicion of prostate cancer. Also, the pretreatment estimation of the volume of prostate cancer can provide important prognostic information after hormonal or radiation therapy. (Terris & Stamey 1991). The commonly used method in measuring prostate volume is the elliptical method. This formula can be transformed into volume = 0.523 x d1 x d2 x d3. Maximal width and height diameters are obtained at the largest appearing mid gland axial image section. The length dimension can be obtained on midline sagittal plane (Fig. 2.8).

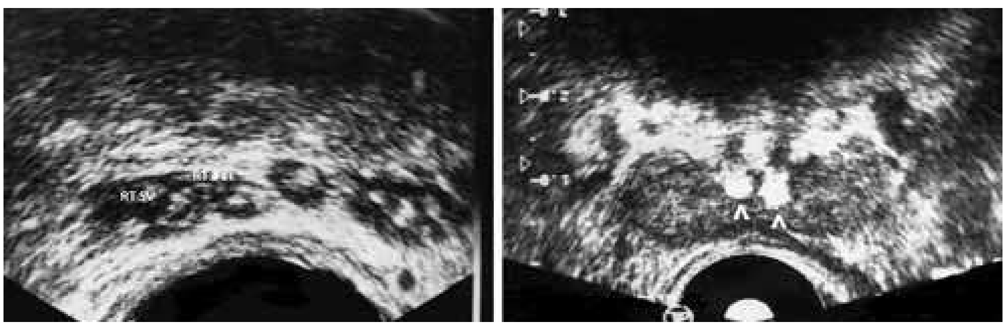

Fig. 2.8. (A) TRUS shows multiple flecks of calcifications seen in both seminal vesicles (SV) and vassal ampulae. (B) TRUS shows bilateral ejaculatory ducts calculi (arrow heads) in a patient with obstructive azospermia

This method is widely used because it is easy and fast method. The fact that it is slightly less accurate than other methods is not documented (Terris & Stamey,1990).

CHAPTER THREE

Material and Methods

3-1. Subjects

Cross-sectional study, included 50 male subjects from the age of 20 years old to 40 years old were selected to undergo the transabdominal ultrasonography scanning.

The subjects were randomly selected with different status, ages and body weights to find the correlation of these parameters to normal prostate volume. Since, this study focuses on normal prostate volume, subjects with the history of abnormal prostate condition were automatically excluded from the study.

B. Prostate Ultrasonographic Scanning Protocols Overall ultrasonographic scanning was conducted by using Siemens Aplio MX.

The subjects were first instructed to fully fill their urinary bladder by consuming water 30 minutes before the measurement. This was to ensure that the anatomy of prostate could be well-imaged and observed. The measurement was conducted by placing the transducer on the superficial of the abdominal area with subjects laid in supine position during scanning.

3-2:Variables of the study:

-size of prostate volume,

-Age

-Weight

-Marital status

-Level of PSA

-Historical urinary disorders

Other co-morbidities, those renal diseases which accompany the prostatic disorder in the kidney or the ureter such as: cystitis , stones, inflammatory changes.

3-3: Data Collection equipments

The device was set to a 2D mode and a convex probe with frequency of 3.5MHz to 5MHz was used for imaging from longitudinal plane as shown in Fig. 3.1 Measurements were conducted under general setting of the ultrasound machine.

Fig (3-1)

Siemens G60 S Machine.

3-4- Scanning patients with ultrasound using the protocol of the Prostate as follows:

3-4-1:Transabdominal technique

The patient lies supine. The patient should have a half full bladder. 500 ml of water 1 hr before the scan, if possible, is recommended. The probe is angled approximately 30 degrees caudal using the bladder as a window. Slight compression to ensure the inferior portion of the prostate is not obscured by the shadow artifact from the base of the bladder. **Trans-abdominal Ultrasound** can assess the volume of the prostate but is not reliable to diagnose carcinoma ,The patient lies supine with amount of gel is poured on the anterior part of pubic region. Sagittal and transverse scanning is then performed to assess the entire prostate in many planes**.**

If the PSA is elevated or increasing rapidly or there is an abnormal prostate examination then a transrectal ultrasound and prostate biopsy may be indicated to obtain tissue to make the diagnosis of prostate cancer.

3-5: **Aquestionnaire of Risk Factors and patient clinical data Assessment Tool**:

A questionnaire designed included basic sociodemographic characteristics, medical history (family history, age, renal diseases (pyelonephritis, stones, vesical pathologies and ureteric obstruction) , Family history of prostatic cancer, , , . Behavior and life style factors.

3-6: Data analysis and presentation:

Data were analyzed using SPSS. Various statistical tests were used according to the type of variables to be interpreted. The data were presented in tables and figures.

3-7 Ethical consideration:

Patients' data were requested by clinicians. The data was collected from those who had been sent to the ultrasound examination or who are selected for evaluation of the prostate. No personnel data will be published.

Chapter Four

Results

This study included 50 healthy male Sudanese subjects . the age ranges from 20 to 40 years old

Table (4-1). Subjects Age description

Age group	Frequency	Percentage
(20-25) yrs	11	22%
(26-30)yrs	20	40%
(31-35) yrs	7	14%
(36-40) yrs	12	24%
Total	50	100%

Table(4-1). Shows the subjects age groups , there are 11(22%) of age class (20-25) yrs , 20(40%) of age class (26-30) yrs. 7(14%) of age class (31-35)yrs and 12(24%) of age class (36-40)yrs. That means the most of the subjects age range (26-30) yrs.

Figure (4-1). Illustration of subjects' age.

there are 11(22%) of age class (20 – 25) years, 20 (40%) of age class (26 – 30) years, 7 (14%) of age class 31 – 35) years and 12(24%) of age class 36 – 40) years.

Table (4-2). Subjects Marital Status

Status	Frequency	Percentage
Single	26	52%
married	24	48%
Total	50	100%

Table (4-2). Shows the subjects marital status , there are 26(52%) single, while 24(48%) were married.. That means the majority of the subjects included in this study were single. Figure 2. Illustrates this graphically.

Figure(4- 2). Description of subjects' marital status

Table (4-3). Variations in subjects Weight, PSA and prostate volume.

No.	**Weight(Kg)**	**PSA**	**PV (cm^3)ml**
1	68	1.69	14
2	85	1.73	14.4
3	62	1.5	12.8
4	58	1.91	15.9
5	55	1.56	13
6	58	1.92	16
7	68	1.35	11.3
8	57	1.71	14.2
9	80	2.92	24.4
10	61	2.06	17.1
11	78	3.29	27.4
12	75	1.39	11.6
13	73	1.84	15.3
14	75	2.4	20
15	64	2.12	17.7
16	60	2.2	18.3
17	64	2.04	17
18	60	1.11	7.8

19	58	1.49	12.4
20	65	1.4	8
21	58	1.36	7.5
22	80	2.25	18.76
23	70	1.01	8.42
24	78	2.36	19.69
25	67	1.89	15.72
26	69	0.94	7.83
27	63	1.2	10.9
28	58	2.2	17.6
29	70	2.5	20.87
30	63	1.96	16.35
31	62	1.7	14.16
32	67	1.53	14.42
33	63	2.5	20.8
34	67	2.36	19.69
35	62	1.94	16.2
36	57	2.15	19.1
37	80	2.04	17.01
38	59	1.66	13.83
39	70	1.65	13.75
40	56	1.86	15.48
41	65	1.39	11.59

42	75	1.87	15.62
43	78	1.00	8.36
44	60	1.62	13.48
45	67	2.15	17.92
46	62	3.6	20.14
47	75	1.65	13.71
48	70	3.56	20
49	69	1.26	10.51
50	73	1.66	13.84
Mean	**66.74**	**1.89**	**15.24**
St.dev	**7.63**	**0.59**	**4.30**

Table)(4-4). Prostate volume and Age correlation

Dependent Variable : Volume						
Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	0.205	12.350	1	48	0.001	10.942	0.179
The independent variable is Age.							

From the above table a linear relationship equation between Age and prostate volume can be estimated as follows:

PV = 0.179 **A** + 10.942 .______________ (1)

Whereas ; **PV** = Prostate volume . **A** = age

Table (4-5). Prostate volume and weight correlation

Dependent Variable :Volume							
Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	0.044	2.195	1	48	0.145	7.369	0.118
The independent variable is Weight.							

From the above table a linear relationship equation between Weight and Prostate volume can be estimated as follows :

PV = 0.118 **w** + 7.369 . _________________ (2)

Whereas; **PV** = Prostate volume . **w** = weight

Table (4-6). Prostate volume and PSA correlation

Dependent Variable :Volume							
Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	0.820	218.532	1	48	0.000	2.746	6.613

The independent variable is PSA.

From the above table a linear relationship equation between PSA and Prostate volume can be estimated as follows:

PV = 6.613 **PSA** + 2.746 . ________________ (3)

Whereas ; **PV** = Prostate volume . **PSA** =

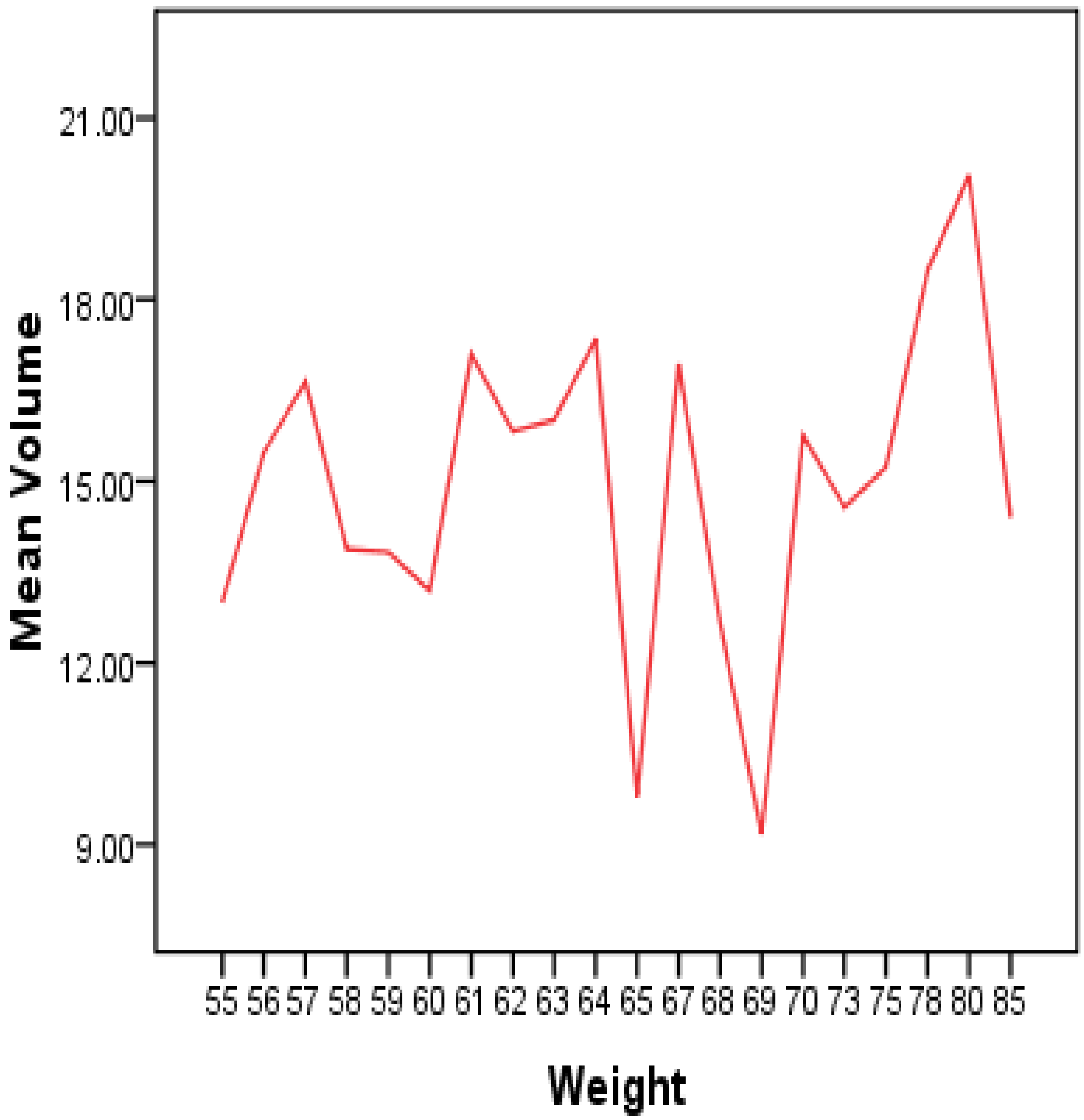

Figure (4-3). Graph of prostate volume and Body weight

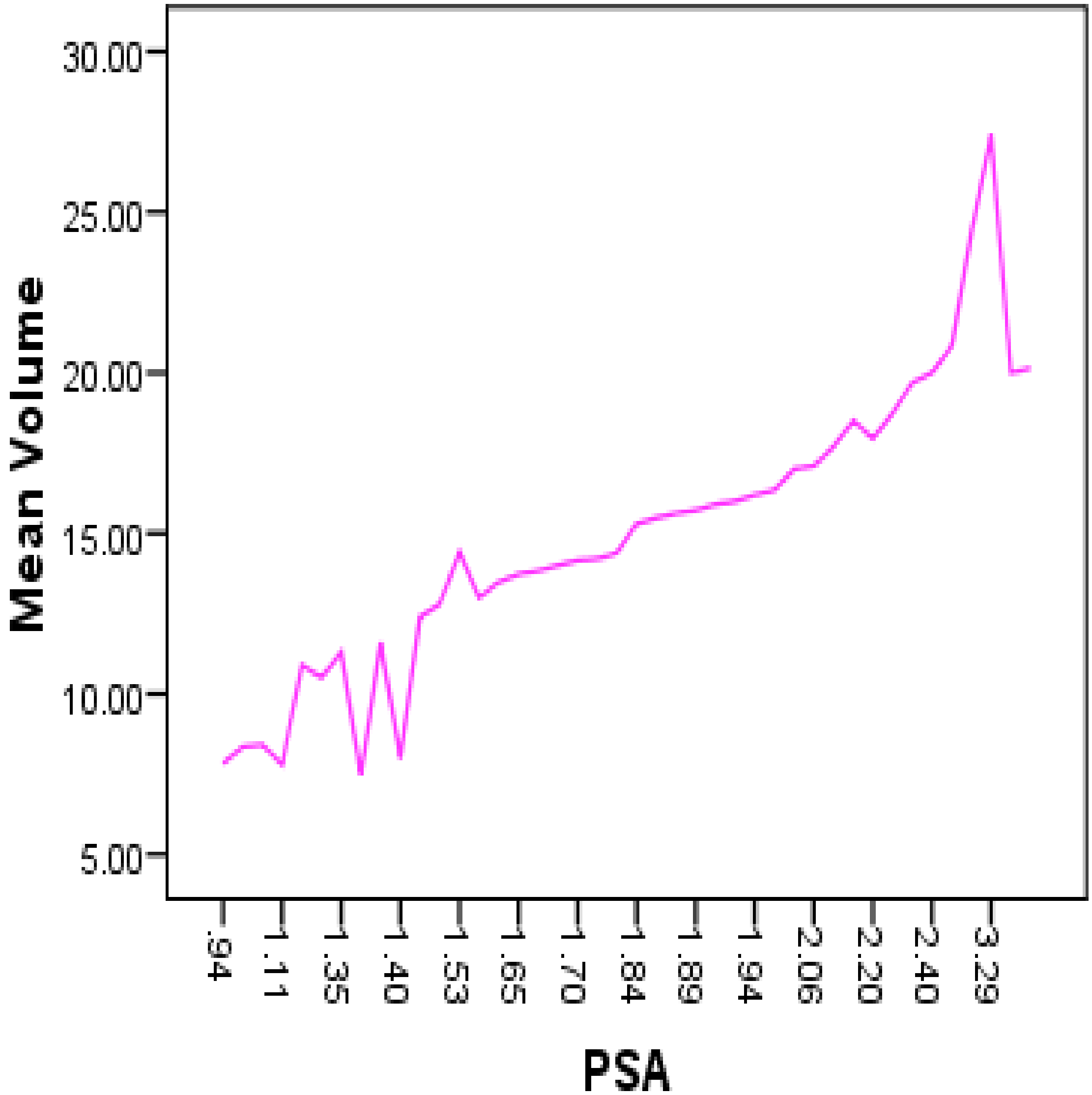

Figure (4-4).Graph of prostate volume and PSA.

Chapter five

Discussion, Conclusion and Recommendation

5-1 Discussion

The final prostate volume measurement result for each subject as well as the subject's weight and PSA is presented by table 3.From the table , it is shown that the calculated volume for all participants, which is achieved from the values of prostate's anteroposterior height, transverse width and cephlocaudal length, ranges from 7.5 ml (cm3) to 27.4 ml (cm3) with mean prostate volume of 15.24 ml (cm3) .

The collected data were plotted into graphical representation to observe the relationship of the prostate volume and body weight as shown by figure 3.

The graph in figure 3 shows a linear relationship between prostate volume and body weight of a male. This means that, as the body weight increases, prostate volume is also increase. Hence, a man with heavier body weight compared to a lighter one will have a larger prostate volume. Body weight of a person reflects the level of human growth and development under the influence of a person's genotype and environment. Genotype and environments reflects mostly on person's ethnicity, which I believed to be the good field for the researchers to study on.

A linear relationship equation between weight and prostate volume can be estimated as follows

PV = 0.118 W + 7.369 .________________ (1)

Were as **PV** = Prostate volume , **W** = weight.

Other than that Figure 4 shows another relationship between prostate volume and a specific antigen that secreted by the prostate gland only, and no other organ, that is the prostate specific antigen. It is observed from the graph that the PSA is dramatically increases with any increasing in the prostate size (volume). Hence , and according to the fact that the prostate is the only source of this antigen , this relationship can be good marker for diagnosis and treatment of prostatic disorders A linear relationship equation between PSA and prostate volume can be estimated as follows:

PV = 6.613 **PSA** + 2.746.___________________ (2)

Were as **, PV** = Prostate volume , . **PSA** = Prostatic specific antigen.

In figure 5 the different age groups in which the prostate was measured can be seen. It is important to point out that the mean prostate volume in the higher percentage frequency age group (26-30) years old , which corresponding to 40%, was 15.5 ml(cm3) , while for the sample total the mean is 15.2 ml(cm3).

The lowest prostate volume measurement was 7.5 ml , and the highest was 27.4 ml, making the mean is 17.5 ml.

Data were analyzed using the STATA program obtaining a sample mean of 15.24 ml and a standard deviation (SD) of 4.30.A 95% confidence interval (CL) with Z values was carried out. The populational mean for prostate volume measured with suprapubic ultrasound in this sample was 15.24 plus or minus 4.30ml.

5.2 Conclusion

- This study shows that using transabdominal approach is an easy, rapid and simple way of prostate measurements. Hence this method can be used as a standard screening method for imaging prostate. There for , transrectal scanning can be used only when necessary or when ambiguity is present during transabdominal scanning.
- This study also found out that prostate volume increases linearly with subject's parameters like age, weight and slightly with marital status.
- There are conflicting data regarding the association between age, obesity and PSA after adjustment for prostate volume. When we examined this relationship we concluded that PSA is negatively associated with obesity and positively associated with prostate volume in all age groups, and not associated with age, unless the prostate size (volume) changes.
- There are few studies on prostate gland volume and weight in young men under the age 40 years old given that no evidence of prostatic disorders or pathology in the general population of men at this age. However prostate volume screening studies in younger men would provide measurement parameters for that age category and therefore would enhance diagnosis and treatment.
- The most frequent ultrasonographic findings were calcifications from amylaceous bodies, periurethral cysts up to 5 mm detected in some subjects within the sample, there was no statistical significance suggesting that these findings causes an increase in prostate volume in men under 40 years of age.

5.3 Recommendations

From the results of this study the researcher recommended that:

- Further study needed to show the relationship between prostate volume and ethnicity by categorizing each subject to their ethnicity background to observe differences of prostate volume between Sudanese populations, for example western population, northern population, eastern and median population to know the prostate volume populational mean obtained from suprapubic ultrasonography in healthy males between age 20 – 40 years in the Sudanese country , and to identifying and documenting the ultrasound imaging findings .
- All sinologists performing prostate scans should be appropriately trained and their results subjected to rigorous audit.
- Performing the scan to a high standard and can demonstrate a good knowledge .
- The ultrasound equipment must be good quality.
- There should be an establishment for normal range of heart aortic diameters and volume for each geographical region.

References

Abou Yousef M M and Naryana AS (1982). Tran rectal ultrasound in the evaluation of the prostatic size. J. Clin ultrasound. 10: 275-278.

Anderson RU, Wise D, Sawyer T, Chan CA (2006). "Sexual dysfunction in men with chronic prostatitis/chronic pelvic pain syndrome: improvement after trigger point release and paradoxical relaxation training". *J. Urol.* **176** (4 Pt 1): 1534–8; discussion 1538–9. doi:10.1016/j.juro.2006.06.010. PMID 16952676.

Benson MC, Whang IS, Pantuck A, Ring K, Kaplan SA, Olsson CA, et al (1992). Prostate cancer: Detection by transrctal sonography. AJR; 155; 811-815.

Evelyn L.M. Ho, "Prostate size: Is size all that matters?", 2010, pp. 1-3.

Evelyn L.M. Ho, "Prostate size: Is size all that matters?", 2010, pp. 1-3.

Hammerer PG, McNeal JE, Stamey TA (1995). Correlation between serum prostate specific imaging in the evaluation of men with symptomatic benign prostatic hyperplasia. Probl urol, 5, 3: 369-379.

Komisaruk, Barry R.; Whipple, Beverly; Nasserzadeh, Sara and Beyer-Flores, Carlos (2009). *The Orgasm Answer Guide*. JHU Press. pp. 108–109. ISBN 0-8018-9396-8. Retrieved 6 November 2011.

Kristal AR, Arnold KB, Schenk JM, *et al.* (2008). "Dietary patterns, supplement use, and the risk of symptomatic benign prostatic hyperplasia: results from the prostate cancer prevention trial". *Am. J. Epidemiol.* **167** (8): 925–34. doi:10.1093/aje/kwm389.PMID 18263602.

Leissner KH, Tisell LE (1979). "The weight of the human prostate". *Scand. J. Urol. Nephrol.* **13** (2): 137–42. doi:10.3109/00365597909181168. PMID 90380.

Marx FJ & Karenberg A, History of the Term Prostate, Prostate, 2009, pp. 208-213.

Morgan, R.; Boxall, A.; Bhatt, A.; Bailey, M.; Hindley, R.; Langley, S.; Whitaker, H. C.; Neal, D. E. et al. (2011). "Engrailed-2 (EN2): A Tumor Specific Urinary Biomarker for the Early Diagnosis of Prostate Cancer". *Clinical Cancer Research* **17** (5): 1090–8.doi:10.1158/1078-0432.CCR-10-2410. PMID 21364037.

Myers, Robert P (2000). "Structure of the adult prostate from a clinician's standpoint".*Clinical anatomy* **13** (3): 214–5. doi:10.1002/(SICI)1098-2353(2000)13:3<214::AID-CA10>3.0.CO;2-N. PMID 10797630.

Naryan P, Foster L (1991). The rule of intravenous urography and magnetic resonance imaging in the evaluation of men with symptomatic benign prostatic hyperplasia. Probl urol, 5, 3: 369-379.

Patel AR, Jones JS, “Optimal biopsy strategies for the diagnosis and staging of prostate cancer”, Curr Opin Urol., 2009, pp. 232-237.

Rajesh Shinghal and Martha K Terris. Limitation of Transperineal ultrasound guided prostate biopsies. Adult Urology 54(4). 1999:706-708

Rajesh Shinghal and Martha K Terris. Limitation of Transperineal ultrasound guided prostate biopsies. Adult Urology 54(4). 1999:706-708

Ravishankar Jayadevappa, Sumedha Chhatre, Jerry C. Johnson, Stanley Bruce Malkowitz, “Association between ethnicity and prostate cancer outcomes across hospital and surgeon volume group”, Health Policy, 2011, pp. (99):97-106.

Rifkin MD (1997). Ultrasound of the Prostate. 2nd edn.Philadelphia, PA: Lippincott-Raven.

Scattoni V, Zlotta A, Montironi R, et al., Extended and saturation prostatic biopsy in the diagnosis and characterisation of prostate cancer: a critical analysis of the literature, Eur Urol. 2007, pp. 1309- 1322.

Sun Ho Kim and Seung Hyup Kim. “Correlation between the various methods of estimating prostate Volume: Transabdominal”, Transrectal and three dimensional US. Korean J. Radiol, 2008(9), pp. 134-139.

Terris MK, and Stamey TA (1991). Determination of prostatic volume by transrectal ultrasound. J Urol, 145: 984-987.

Terris MK, McNeal JE, Stamey TA (1990). Invasion of the seminal vesicles by prostatic cancer: Detection by transrctal sonography. AJR; 155; 811-815.

Walz J, Graefen M, Chun FK, et al., High incidence of prostate cancer detected by saturation biopsy after previous negative biopsy series, Eur Urol. 2006, pp. 498-505.

Walz J, Graefen M, Chun FK, et al., High incidence of prostate cancer detected by saturation biopsy after previous negative biopsy series,Eur Urol. 2006, pp. 498-505.

Appendices

Appendix (1) images

Image (1) 27 years old marriage 36 Kg male.

Prostate volume measured 16.4 ml.

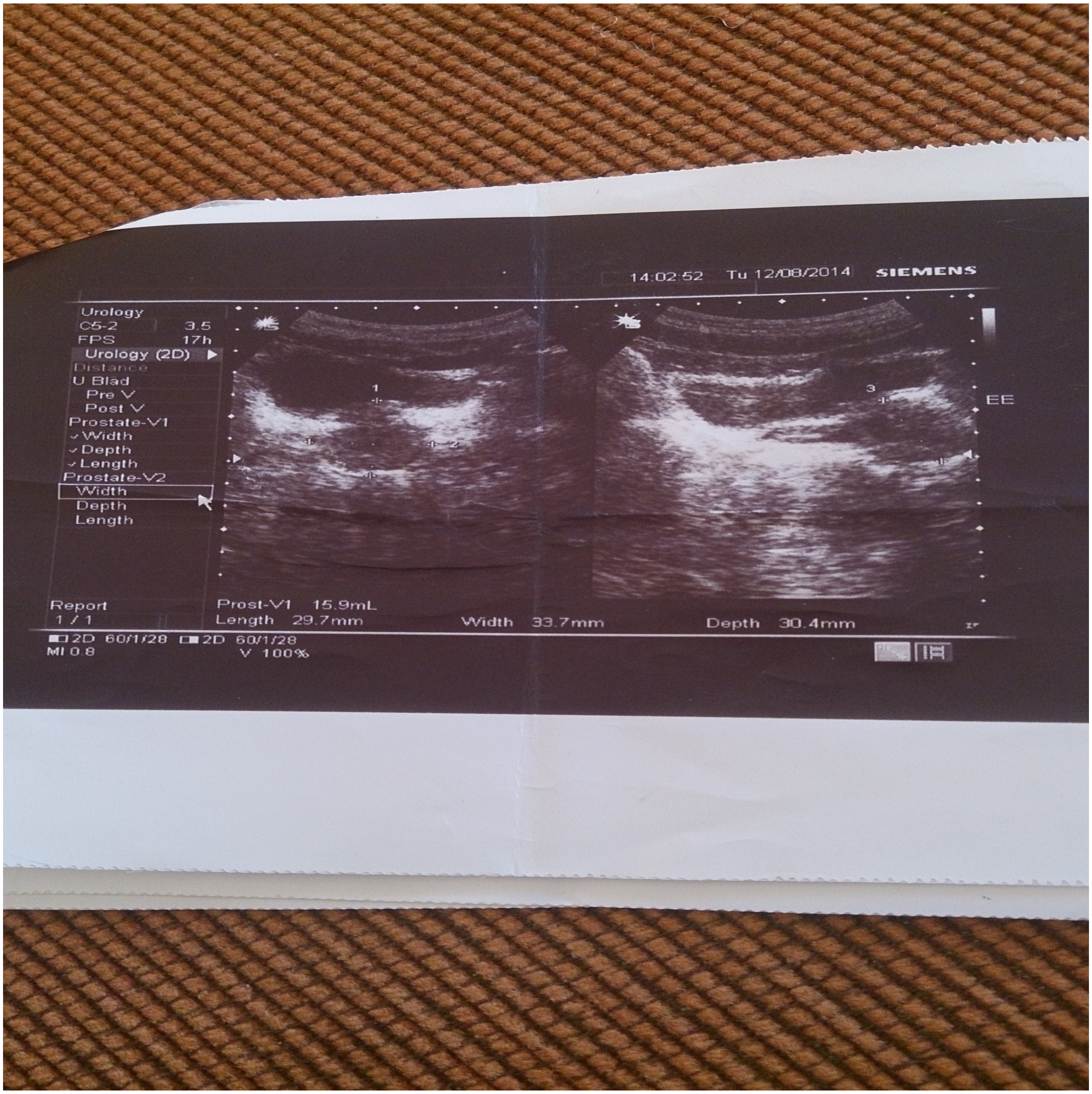

Image (2) 23 years single 58 Kg male.

Prostate volume measured 15.9 ml.

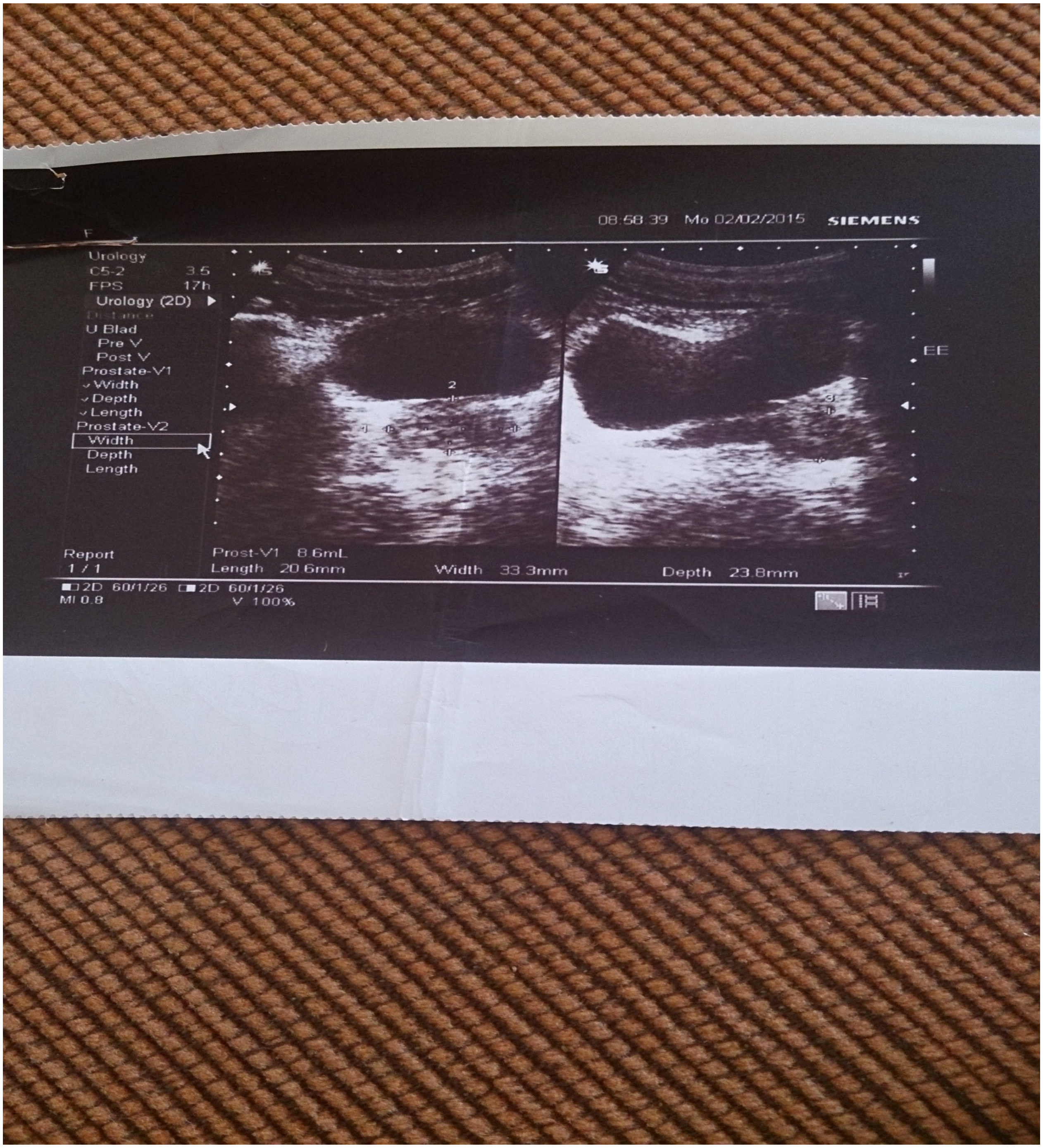

Image (3) 30 years old single 65 Kg male.

Prostate volume measured 8.6 ml.

Image (4) 36 years old single 75 Kg male.

Prostate volume measured 11.6 ml.

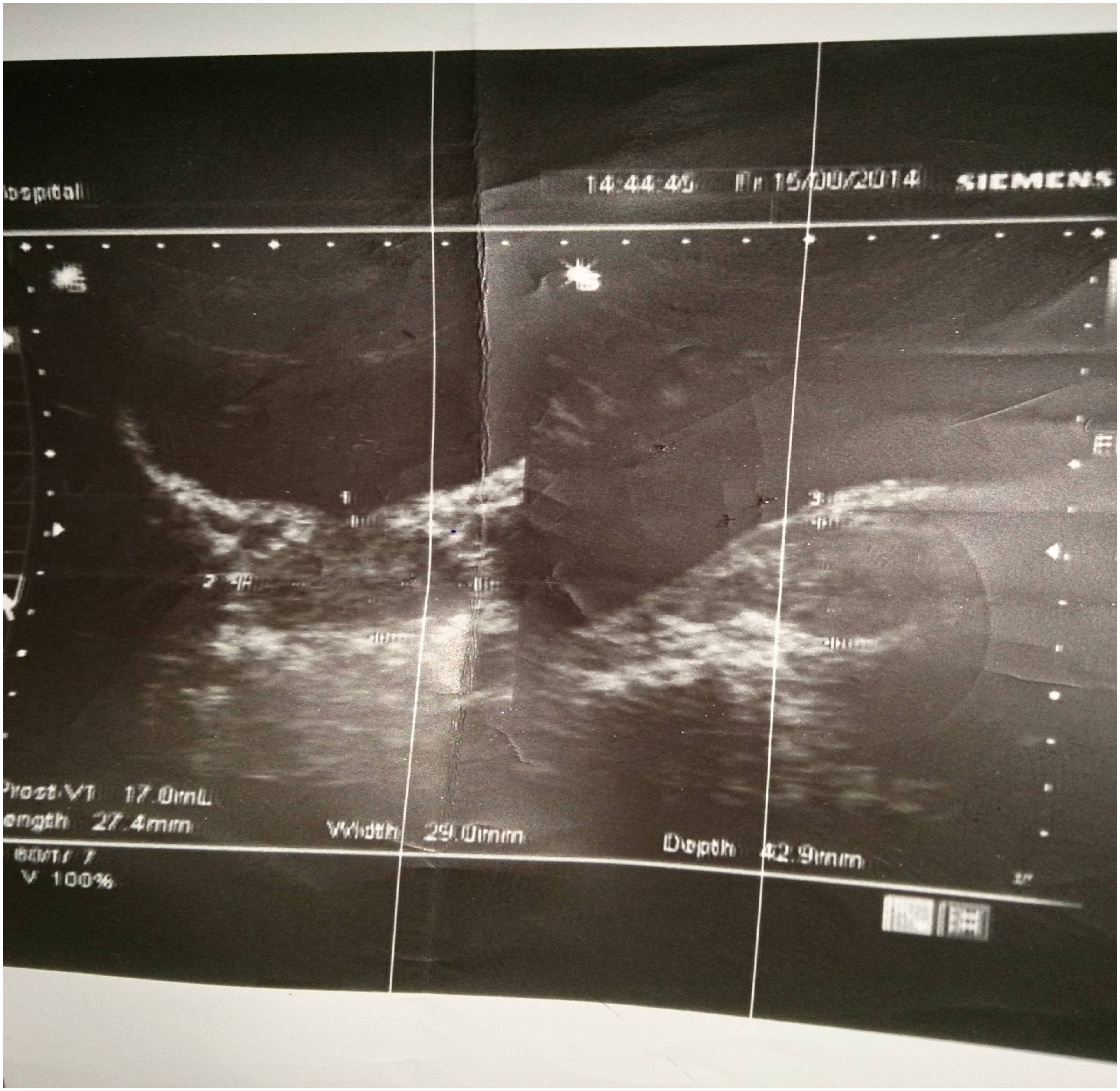

Image (5) 22 years old , 64 Kg single male.

Prostate volume measured 17.0 ml.

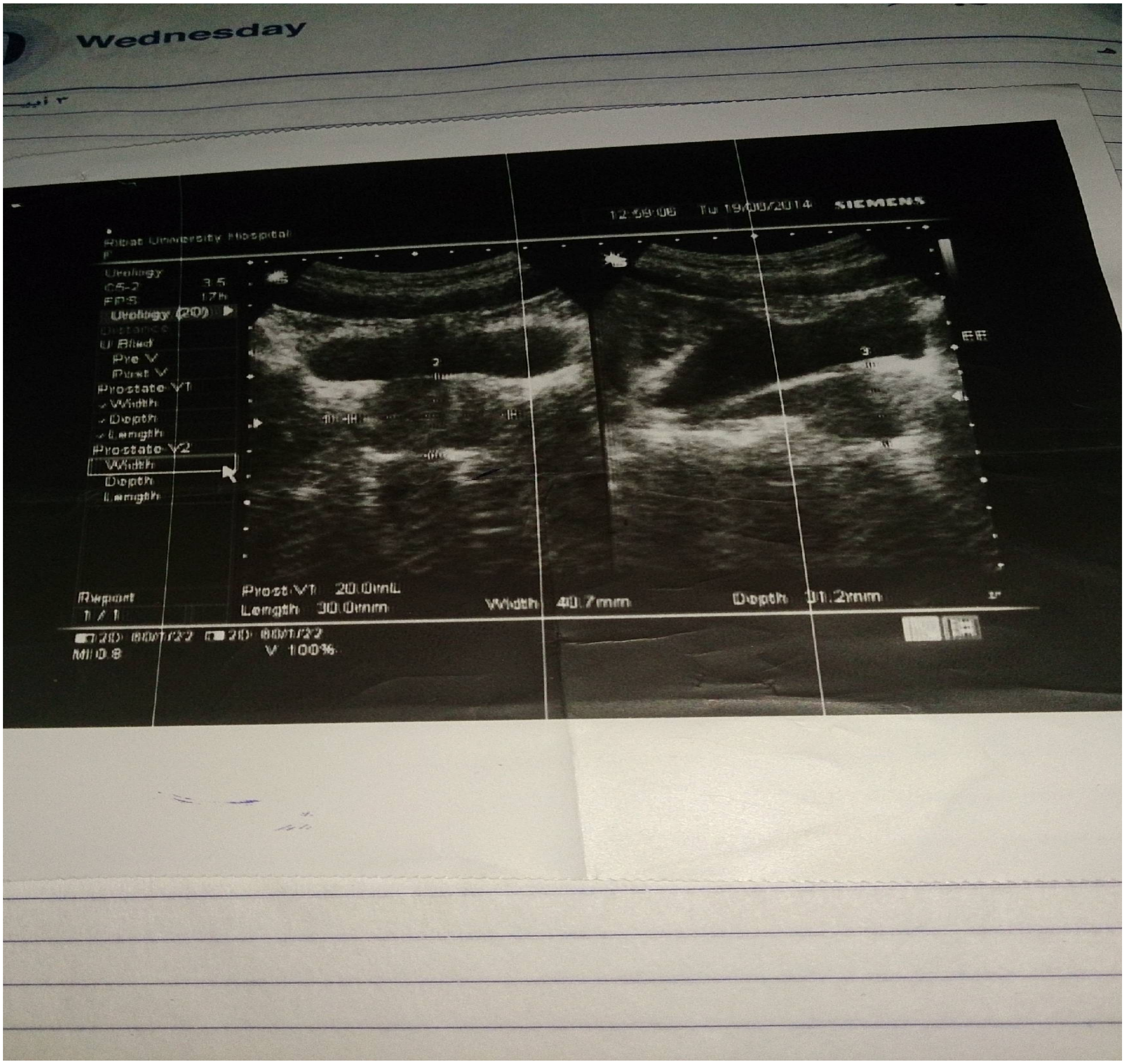

Image (6) 33 years old , 75 Kg marriage male.

Prostate volume measured 20.0 ml.

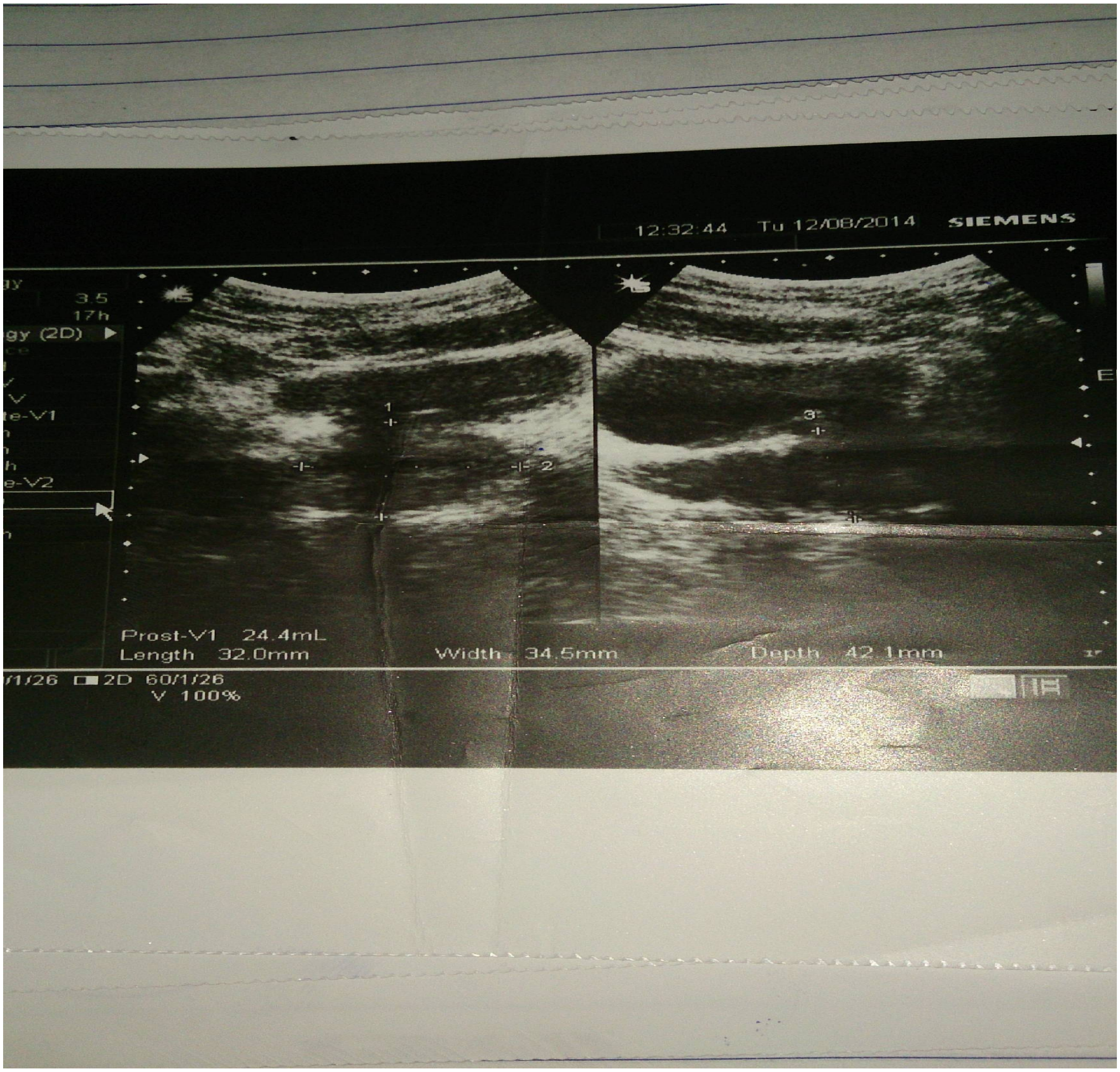

Image (7) 39 years old , 80 Kg marriage male.

Prostate volume measured 24.4 ml.

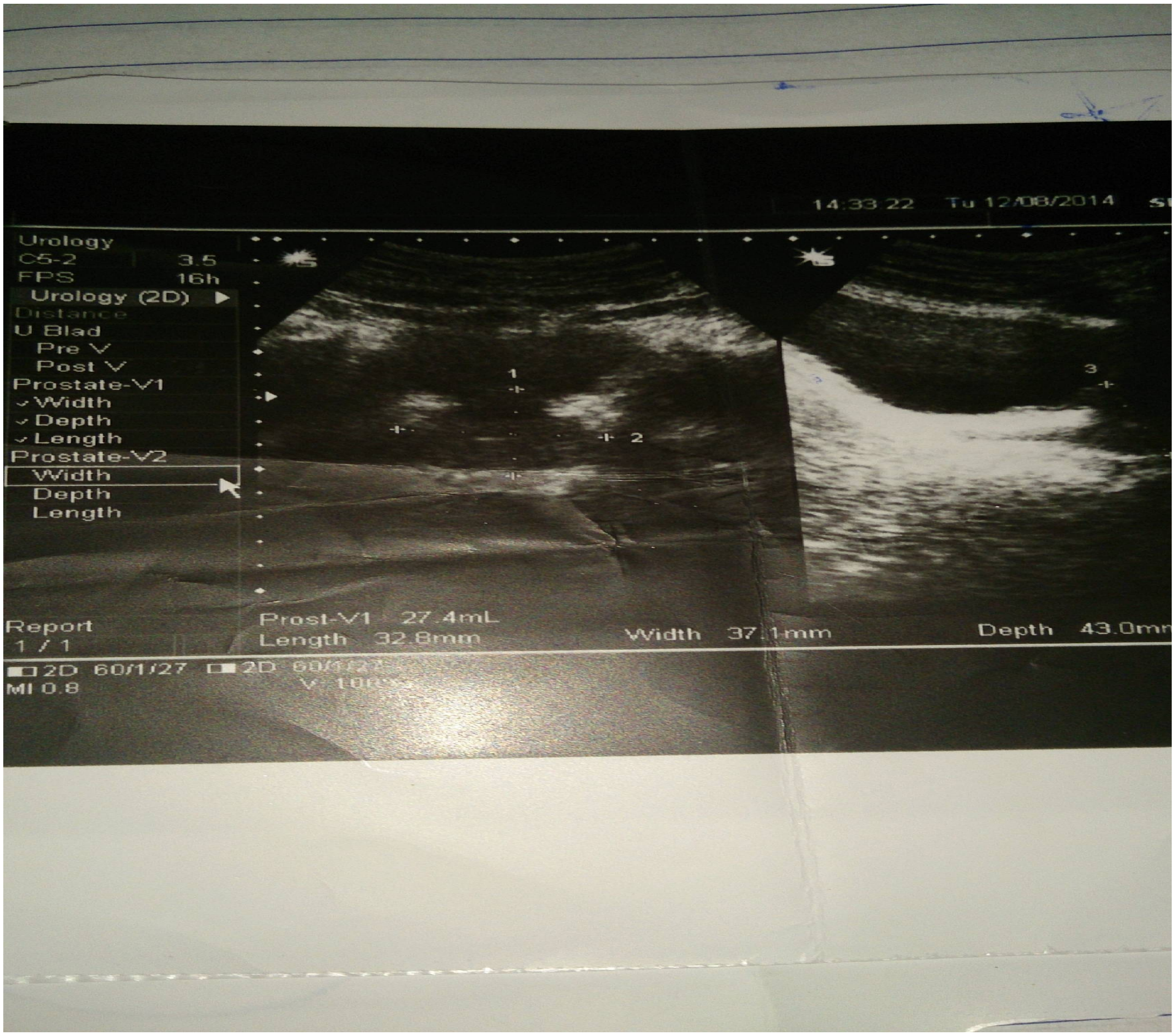

Image (8) 37 years old , 78 Kg marriage male.

Prostate volume measured 27.4 ml.

Image (9) 40 years old , 75 Kg marriage male.

Prostate volume measured 15.5 ml.

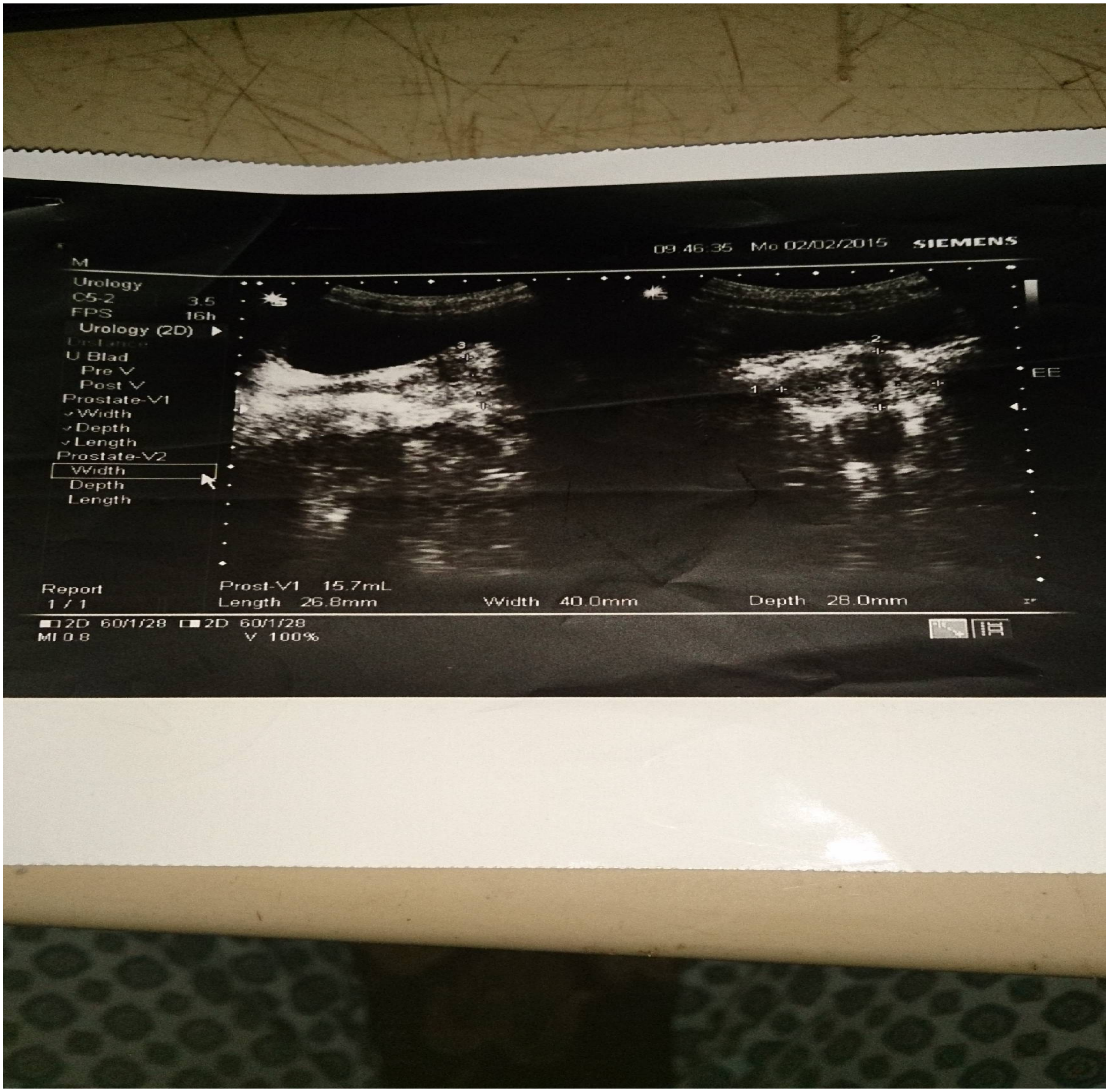
09:46:35 Mo 02/02/2015
SIEMENS
M
Urology
C5-2 3.5
FPS 16h
Urology (2D)
U Blad
Pre V
Post V
Prostate-V1
Width
Depth
Length
Prostate-V2
Width
Depth
Length
EE
Report
1 / 1
Prost-V1 15.7mL
Length 26.8mm
Width 40.0mm
Depth 28.0mm
2D 60/1/28 2D 60/1/28
MI 0.8
V 100%

Image (10) 35 years old , 67 Kg single male .

Prostate volume measured 15.7 ml.

DATA COLLECTION SHEET

Subject No.	Age	Weight	Social status		measurements			Prostate volume	PSA level
			Single	marriage	Length	depth	width		