Introduction

The number of men diagnosed with prostate cancer is increasing through out the world ***(Yancik, 2005)***.

At the time of diagnosis, prostate cancer is organ confined in 70% of the cases. Approximately a quarter of these patients undergo local therapy: surgery or external beam radiation. Because patients often do not fit these treatments, the quest continues for a reliable and minimally invasive alternative to open surgery or external beam radiation.

Radical prostatectomy and radiotherapy remain the primary treatments for patients with localized prostate cancer. On one hand, these therapies are not free of significant complications and risks, on the other hand some patients are not suitable for major surgical procedures or cannot tolerate tradition therapy because they have co-morbid medical conditions or have already been treated earlier in life.

Several treatment modalities have faced the surface in the armamentarium of the management of localized prostate cancer brachytherapy, cryotherapy and HIFU.

HIFU destroys prostate cells by coagulative necrosis of the tissue ***(Chapclon et al., 1992)*** without damaging the intervening structures passed by HIFU and without an increase in metastasis formation ***(Oosterhof et al., 1997)***.

For imaging purposes, this deposited energy is insignificant. However, by increasing the intensity of the waves and focusing them on a single point, HIFU deposits large amounts of energy into tissues, thus resulting in their destruction.

Two mechanisms of tissue damages are involved: thermal effect and cavitations ***(Kennedy et al., 2003).***

HIFU can also be considered as a salvage treatment for radiation and brachytherapy failure ***(Gelet et al., 2004).***

High intensity focused ultrasound has the potential to provide clinician with another truly non-invasive, targeted treatment option in targeting local prostate cancer.

Historically the initial work on ultrasound in the treatment of the benign prostatic hyperplasia(BPH) began in the early 1990s, but already during the 1950s, the Fry brothers imagined the first medical application of ultrasonic waves By 1956, Burov had suggested that high intensity ultrasound could be used for the treatment of cancer ***(Azzouz and de la Rosette, 2006).***

At the end of 80s, studies using HIFU to irradiate experimental tumors followed ***(Fry et al., 1978).***

Real - time feedback during treatment allows HIFU induced lesions to be visible using standard ultrasound as hyperechoic areas, but their extent is not always accurately defined. For posttreatment follow- up, MRI is the gold standard in evaluating the treatment efficacy of HIFU ***(Rouviere et al., 2001).***

MRI has also been used to guide FIIFU treatment and to monitor temperature changes during HIFU ***(de Senneville et al., 2007).***

Aim of the Work

The main purpose of this essay is to discuss the applications of high intensity focused ultrasound (HIFU), in the management of localized prostate cancer with detailed discussion of its indications, results and possible complications.

Chapter (1)

Anatomy of the Prostate

Anatomic Relationships

The prostate is a pyramidal fibromuscular gland which surrounds the prostatic urethra from the bladder base to the membranous urethra and is itself surrounded by a thin but tough connective tissue capsule. It lies at a low level in the lesser pelvis, behind the inferior border of the symphysis pubis and pubic arch and anterior to the rectal ampulla, through which it may be palpated. Being somewhat pyramidal, it presents a base or vesical aspect superiorly, an apex inferiorly and posterior, anterior and two inferolateral surfaces. The prostatic base measures about 4 cm transversely. The gland is 2 cm in anteroposterior and 3 cm in its vertical diameters, and weighs 8 g in youth, but almost invariably enlarges with the development of benign prostatic hyperplasia (BPH), weighing usually. 40 g, but sometimes as much as 150 g or even more after the first five decades of life ***(Uhlenhuth, 1953)***. Superiorly the base is largely contiguous with the neck of the bladder. The urethra enters the prostate near its anterior border. The apex is inferior, surrounding the junction of the prostatic and membranous parts of the posterior urethra.

The anterior surface lies in the arch of the pubis, separated from it by a venous plexus (Santorini's plexus) and loose adipose tissue. It is transversely narrow and convex, extending from the apex to the base. Near its superior limit it is connected to the pubic bones by the puboprostatic ligaments. The urethra emerges from this surface anterosuperior to the apex of the gland. The anterior part of the prostate is relatively deficient in glandular tissue and is largely composed of fibromuscular tissue ***(Uhlenhuth, 1953).***

The inferolateral surfaces are related to the muscles of the pelvic sidewall: the anterior fibres of levator embrace the prostate in the pubourethral sling or pubourethralis. These muscles are separated from the prostate by a thin layer of connective tissue ***(Hinman and Saunder, 1993)***. The posterior surface is separated from the rectum by the prostatic capsule and by Denonvillier's fascia, a dense condensation of pelvic fascia which develops by obliteration of the rectovesical peritoneal pouch. It is obliterated from below upwards as fetal life progresses so that at birth this fascia separates the prostate, the seminal vesicles and the ampullae of the vasa deferentia from the rectum. The posterior surface is transversely flat and vertically convex. Near its superior (juxtavesical) border is a depression where it is penetrated by the two ejaculatory ducts. Below this is a shallow, median sulcus, usually considered to mark a partial separation into right and left lateral lobes ***(Hinman and Saunder, 1993)***.

The anterior and lateral aspects of the prostate are covered by a layer of fascia derived from the endopelvic fascia on each side. The prostatic venous plexus lies between this extension of the endopelvic fascia and the capsule of the prostate. Anteroinferiorly the fascia and the capsule of the prostate merge and blend with the puboprostatic ligaments ***(Hinman and Saunder, 1993).***

The apex of the prostate is continuous with the striated urethral sphincter. Histologically, normal prostatic glands can be found to extend into the striated muscle with no intervening fibromuscular stroma or "capsule." At the base of the prostate, outer longitudinal fibers of the detrusor fuse and blend with the fibromuscular tissue of the capsule. As mentioned, the middle circular and inner longitudinal muscles extend down the prostatic urethra as a preprostatic sphincter. As with the apex, no true capsule separates the prostate from the bladder. In surgically resected prostate carcinomas, this peculiar anatomic arrangement can make interpretation of these margins difficult and has led some pathologists to propose that the prostate does not possess a true capsule ***(Hinman and Saunder, 1993)***.

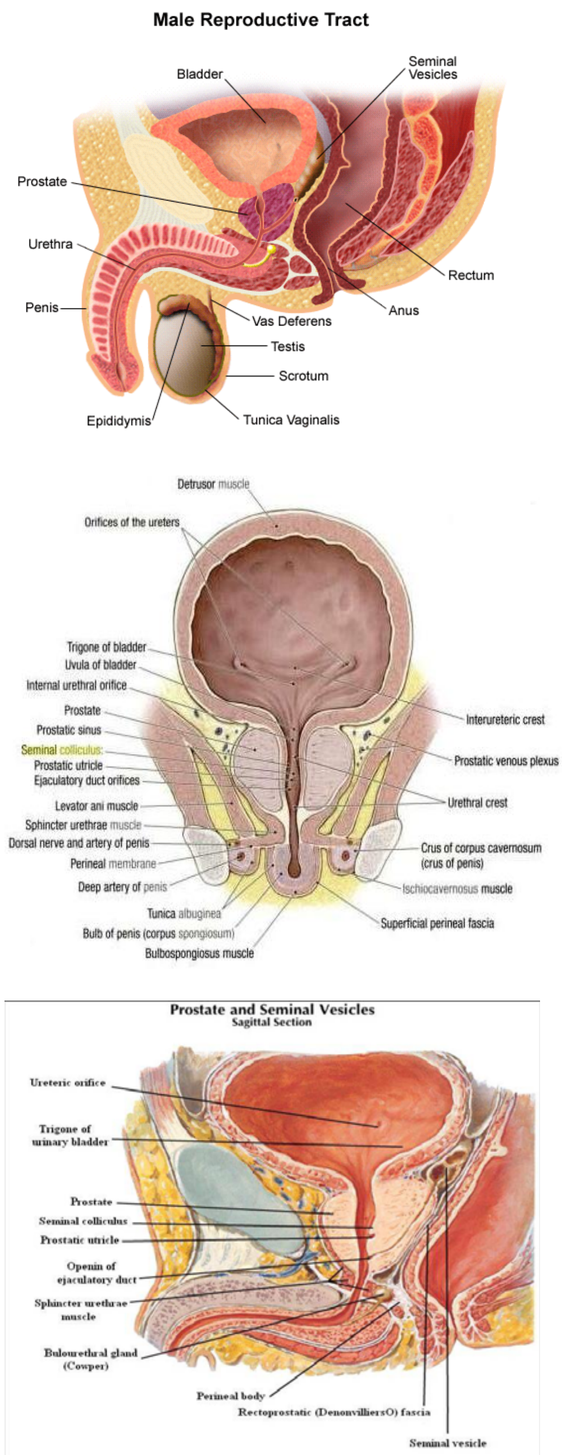

Fig. (1): Anatomy and relation of the prostate ***(Elsevier Ltd 2005. Standring: Gray's Anatomy 39e- www-graysanatomy online.com)***

The zonal anatomy

The prostate gland was initially thought to be divided into five anatomical lobes, but it is now recognized that five lobes can only be distinguished in the fetal gland prior to 20 weeks' gestation. Between then and the onset of BPH, three lobes are recognizable, two lateral and a median lobe. This simplified view of prostatic lobation is retained because clinicians refer to left and right 'lobes' when describing rectally palpable and endoscopically visible abnormalities in the diseased state when prostatic anatomy is distorted by BPH ***(Mc Neal, 1988)***.

From an anatomical and particularly from a morbid anatomical perspective, the glandular tissue may be subdivided into three distinct zones, peripheral (70% by volume), central (25% by volume), and transition (5% by volume). Non-glandular tissue (fibromuscular stoma) fills up the space between the peripheral zones anterior to the preprostatic urethra. The central zone surrounds the ejaculatory ducts posterior to the preprostatic urethra and is more or less conical in shape with its apex at the verumontanum. The transition zone lies around the distal part of the preprostatic urethra just proximal to the apex of the central zone and the ejaculatory ducts. Its ducts enter the prostatic urethra just below the preprostatic sphincter and just above the ducts of the peripheral zone. The peripheral zone is cup-shaped and encloses the central transition zone and the preprostatic urethra except anteriorly, where the space is filled by the anterior fibromuscular stoma. Simple mucus-secreting glands lie in the tissue around the preprostatic urethra, above the transition zone and surrounded by the preprostatic sphincter. These simple glands are similar to those in the female urethra and unlike the glands of the prostate ***(Mc Neal, 1988)***.

The zonal anatomy of the prostate is clinically important because most carcinomas arise in the peripheral zone, whereas BPH affects the transition zone, which may grow to form the bulk of the prostate. BPH begins as micronodules in the transition zone; these grow and coalesce to form macronodules around the inferior margin of the preprostatic urethra, just above the verumontanurn. The central zone surrounding the ejaculatory ducts is rarely involved in any disease. It shows certain histochemical characteristics which are different from the rest of the prostate and is thought to be derived from the Wolffian duct system (much like the epididymi, vasa deferentia and seminal vesicles), whereas the rest of the prostate is derived from the urogenital sinus ***(Mc Neal, 1988)***.

The zonal anatomy may be distinguished to some extent on radiological imaging. On transrectal ultrasonography (TRUS) the central and peripheral zones are generally of uniform low-level echogenicity, although slight differences may be appreciated. The preprostatic urethra is surrounded by a less echogenic area which corresponds to the preprostatic sphincter, periurethral glandular tissue and transition zone. It is often possible to see the ejaculatory ducts coursing to the prostatic urethra on sagittal scans of the gland. The seminal vesicles are hypoechoic/anechoic sacculated structures which lie superoposterior to the gland ***(Mc Neal, 1988)***.

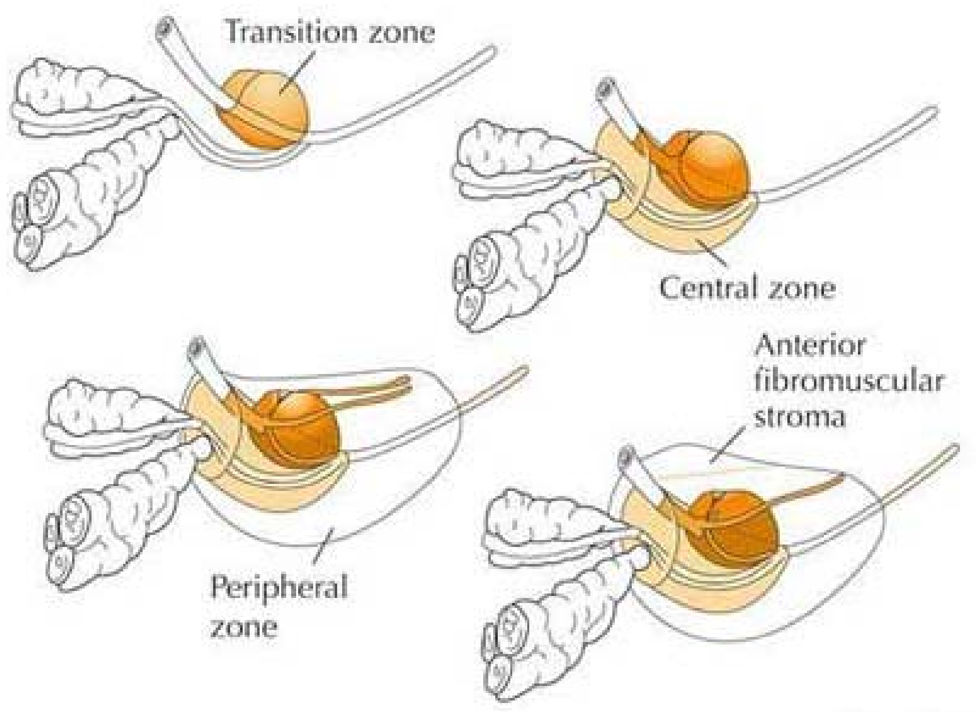

Fig. (2): Zonal anatomy of the prostate as described by J.E Me Neal (Am J Surg Pathol 1988; 12:619-633). The transition zone surrounds the uretha proximal to the ejaculatory ducts. The central zone surrounds (he ejaculatory ducts and projects under the bladder base. The peripheral zone constitutes the bulk of the apical, posterior, and lateral aspects of the prostate.

Vascular Supply

ARTERIES: Most commonly, the arterial supply to the prostate arises from the inferior vesical artery. As it approaches the gland, the artery (often several) divides into two main branches.

The urethral arteries penetrate the prostatovesical junction posterolaterally and travel inward, perpendicular to the urethra. They approach the bladder neck in the 1- to 5-o'clock and 7- to 11 -o'clock positions, with the largest branches located posteriorly. They then turn caudally, parallel to the urethra, to supply it, the periurethral glands, and the transition zone. Thus, in benign prostatic hypertrophy, these arteries provide the principal blood supply of the adenoma.

When these glands are resected or enucleated, the most significant bleeding is commonly encountered at the bladder neck, particularly at the 4- and 8-o'clock positions ***(Williams et al., 1989)***.

The capsular artery is the second main branch of the prostatic artery. This artery gives off a few small branches that pass anteriorly to ramify on the prostatic capsule. The bulk of this artery runs posterolateral to the prostate with the cavernous nerves (neurovascular bundles) and ends at the pelvic diaphragm. The capsular branches pierce the prostate at right angles and follow the reticular bands of stroma to supply the glandular tissues ***(Williams et al., 1989).***

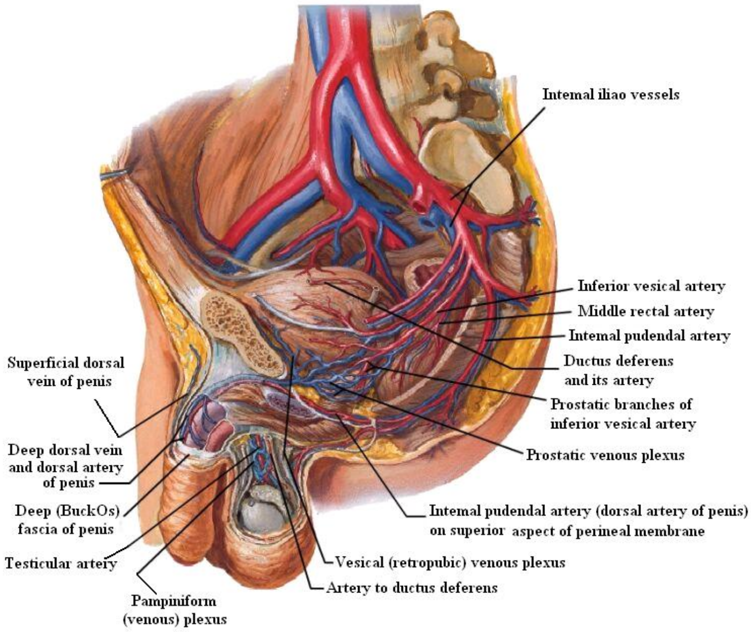

Fig. (3): ***Arterial supply of the prostate*** © Elsevier Lid 2005. Standring: Gray's Anatomy 39e - www.qravsanatornvonUne.com *I* Arteries of the male pelvis. The internal iliac vein and Its tributaries and the rectum have been omitted for clarity.

VEINS: The veins run into a plexus around the anterolateral aspects of the prostate, posterior to the arcuate pubic ligament and the lower part of symphysis pubis, anterior to the bladder and prostate. The chief tributary is the deep dorsal vein of the penis. The plexus also receives anterior vesical and prostatic rami (which connect with the