PROSTATIC INTERVENTIONS

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Abstract: *Prostate interventions are mostly focused on the diagnosis and treatment of the malignancy of the gland. Image guided interventions of the prostate are almost exclusively done under transrectal USG (TRUS) guidance, while CT is being used to plan external beam radiation therapy and brachytherapy. MR guided procedures are now gradually becoming popular. Prostatic Interventions include TRUS or MR Image guided biopsy as well as Image guided therapeutic procedures, such as radiofrequency ablation in malignancy of the prostate. Its role in non malignant conditions of prostate includes abscess drainage and aspiration of prostatic cysts. Majority of the procedures performed on prostate are as good as surgical procedure for the treatment of localized prostatic malignancy.*
Key Words: Prostate interventions: Image guided biopsy: Brachytherapy, Cryo-ablation and Radiofrequency ablation

INTRODUCTION

The prostate is an organ that is located deep within the male pelvis. Prostate interventions are mostly focused on the diagnosis and treatment of the malignancy of the gland[1,2]. Endoscopic methods (cystourethroscopic) are widely practiced for the treatment of prostatic hyperplasia and some benign pathologies. Imaging of the gland is best achieved by Ultrasonography (USG) and/ or Magnetic Resonance Imaging (MRI). Computed Tomography (CT) can only used to stage the cancer of the prostate as the contrast resolution of this modality is relatively inferior. Image guided interventions of the prostate are almost exclusively done under transrectal USG (TRUS) guidance, while CT is being used to plan external beam radiation therapy and brachytherapy. MR guided procedures are now gradually becoming popular[3,4].

PROSTATE - ANATOMY

The prostate is a variable-sized gland located in the male pelvis, measuring 3-4 centimeters long by 3-5 centimeters in width. On average the adult gland weighs approximately 20 grams. It is found behind the pubic bone, in front of the rectum, and below the bladder, surrounded by the pelvic muscles. The prostate has various concentric zones. These zones are termed: anterior fibromuscular stroma, peripheral zone, central zone, and transition zone. Almost all prostate cancers start in the peripheral zone. The transition zone generally accounts for less than 5% of the total prostate volume. Nonetheless, it is the exclusive site for the development of benign prostatic hyperplasia (BPH) and may become massive. The central zone is not commonly associated with any disease process. The anterior fibromuscular stroma is the anchoring point of the urethral sphincter that controls urination. It does not have any glands and therefore cancer or benign enlargement does not develop here[5].

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PROSTATIC INTERVENTIONS

The various procedures done (or assisted) by a radiologist under image guidance are given in Table 1.

Table 1 : *Overview of Prostatic interventions*

Prostatic interventions
1 Malignancy of the prostate
a) Image guided biopsy- (i) TRUS guided- (ii) MR guided.
b) Image guided therapeutic procedures- TRUS guided - MR guided.
I. Brachytherapy; II. Cryoablation
III. Radiofrequency ablation (RFA)
2 Nonmalignant conditions of prostate
a) Abscess drainage
b) Aspiration of prostatic cysts

MODALITY OF CHOICE FOR GUIDANCE – USG OR MRI?

In our institute TRUS is almost exclusively used to guide procedures. But recent literature points that MR can also be used for the purpose with good results[3,4,6]. CT is used only for planning the procedure and guidance during the procedure is usually provided by TRUS. The role of USG, especially TRUS will be emphasized upon in this article.

IMAGE GUIDED PROSTATE BIOPSY

Although not a prostate 'intervention' in the true sense, this procedure is the commonest to be performed in routine urologic practice. In contemporary practice, most prostate cancers are either invisible on ultrasound or indistinguishable from concurrent benign prostatic hyperplasia. Diagnosis therefore rests on prostate biopsy. Biopsies are not simply directed at ultrasonically visible lesions, as these would miss

many cancers; rather representative areas in the whole gland are sampled. The sampling itself is systematic, using patterns based on prostate zonal anatomy and the geographical distribution and frequency of cancer. Thus the whole gland is sampled under image guidance with sample(s) taken from any visible lesion as well[1]. For cancer diagnosis, TRUS on its own has a positive predictive value of 6% if prostate specific antigen (PSA) and digital rectal examination (DRE) are normal[7].

The identification of a high-risk group is an area of a continuing debate and shifting consensus, but currently an abnormal DRE and/or elevated PSA (greater than 4 ng/ml or the age-corrected level) is taken to signify an increased risk of prostate cancer[1,8]. There has been many modifications of the prostate biopsy technique, from the classical sextant biopsy method consisting of 6 cores to the more recent extended biopsy protocols that may include 8, 10, 12, >12 and saturation biopsy protocols. Extended protocols are increasingly being used to improve diagnostic accuracy, especially in those patients who require repeat biopsy[1].

Prostate biopsy can be performed through transrectal as well as transperineal approaches. The former is generally preferred. The first step for TRUS guided biopsy is patient preparation. This consists of performing cleansing enema (proctoglycs) 2-6 hours before biopsy. This could be self administered. Prophylactic antibiotics are also administered. We give Ciprofloxacin-Tinidazole (500 mg) combination twice a day for 3 days beginning a day before biopsy. Differences may be found locally in the type, dosage and the duration of this pre-procedure medication. For local anesthesia, lidocaine has been proposed, which may be used as a gel applied in the rectum or in the form of a prostate infiltrate.

The patient is placed in prone or left lateral position and the biopsy needle is introduced in tandem with the probe through either an externally mounted guide or an in-built channel within the probe. Then under image guidance several samples are obtained at each target site. The number of target sites varies with different protocols with the underlying notion that an increase in number of samples leads to an increase in the diagnostic yield. We normally take six samples- two samples each from apex, base and the lateral aspect of the mid portion of the gland. The sample(s) from the additional suspicious areas could also be taken. The prostatic tissue so obtained is subjected to histological grading (Gleason's score). Higher the grade, more malignant is the cancer. This grading has important bearing in the patient management and influences the choice of therapy. Sample(s) may be obtained from the seminal vesicle when involvement is suspected. Nowadays MR guided biopsy is also becoming popular as MR spectroscopy reveals additional foci suspicious for cancer[3,4].

Bleeding, pain/discomfort (including dysuria), infectious complications, vasovagal episodes, urinary retention, epididymitis, periprostatic hematoma, disseminated intravascular coagulopathy (DIC) are the complications that can potentially occur following the procedure[9]. Of these mild self-limiting bleeding (haematuria, rectal bleeding or hematospermia) lasting a few days (average 5 days for hematuria) is the commonest complication, but severe hemorrhage requiring hospitalization is rare. When it occurs, this severe bleeding is nearly always from a rectal vein or artery. It may occur some hours post-biopsy although usually on the day of the procedure. Because of its infrequency, management has not been clearly defined.

IMAGE GUIDED THERAPEUTIC PROCEDURES FOR PROSTATIC MALIGNANCY

Organ-confined prostate cancer can be effectively treated with surgery, 3-dimensional conformal radiation therapy, prostate brachytherapy, cryoablation, radiofrequency ablation[10,11,12]. Apart from these accepted methods there are numerous other non-surgical methods that focus on in situ parenchymal ablation viz., laser, chemicals, photosensitive agents, high intensity focused ultrasound (HIFU) etc[13,14]. Each treatment must be individualized.

BRACHYTHERAPY

Brachy (near) therapy involves the direct implantation of radioactive isotopes into the prostatic parenchyma. The use of radioactive seed implants for prostate cancer is not new. This technique has long held promise as a method of delivering a very high dose of radiation to the prostate while simultaneously reducing the amount of radiation to the adjacent organs such as the bladder or the rectum. Along with advances in medical imaging technology, efficient and effective means of planning and monitoring the placement of seeds have been developed[15]. The most widely used have been CT planning and TRUS guidance. The advantage of modern implant techniques is the avoidance of surgery.

The initial step is the determination of the prostate volume and a rendering of its spatial geometry which is done either using TRUS or CT studies. Then the method of seed (radioactive implant) loading is determined. These methods give either a uniform distribution (Quimby method) or a peripherally weighted distribution (Patterson-Parker system) sparing the prostatic urethra. Finally computerized preplanning is performed that determines the exact location and the strength of the seeds to provide optimal irradiation. The seeds are placed in the prostate by needles through the perineal skin under anesthesia in an operating room environment. This is done with the patient in lithotomy position and takes about an hour. The template, a multichannel needle-steering device corresponding to the electronic grid matrix superimposed on the prostate images, is attached to the rectal probe. The probe is adjusted until the sequential images on the monitor correlate with similar images from the conformal planning studies and then the support brackets are locked in position. The implant takes place using either preloaded needles or with a Mick

applicator, where the seeds are contained in a carrier. After needle insertions, cystoscopy is performed to look for any stray seeds in the bladder or urethra which are removed and reinserted. CT scans with three-dimensional reconstruction can be performed afterward to confirm appropriate dosimetric geometry (Fig.1).

Post procedure morbidity includes moderate proctitis, urethral complications, and impotence each occurring in about 10%. The rate increases in older patients with a history of TURP or radiation therapy [(16)]. In patients with low-grade, small to nonpalpable lesions with a PSA value of less than 10 ng/ml, brachytherapy is associated with a 90% success rate. Patients with more advanced tumors or tumors with aggressive histology show a poor response with clinical failure occurring in 18% to 32%[17].

CRYOABLATION

Cryoablation is a form of cryotherapy for prostatic malignancy that involves the controlled freezing of the prostate gland in order to destroy cancerous cells. The damage caused by freezing occurs at several levels: molecular, cellular and whole tissue structure. Important factors influencing freezing injury are the rate of temperature reduction after the initiation of freezing, the time cells remain frozen and the subsequent heating rate during thawing. During cryoablation of the prostate, the surrounding connective tissue and the smallest blood vessels are also damaged and subsequently have an inadequate blood supply that is believed to slow the growth of cancer[18].

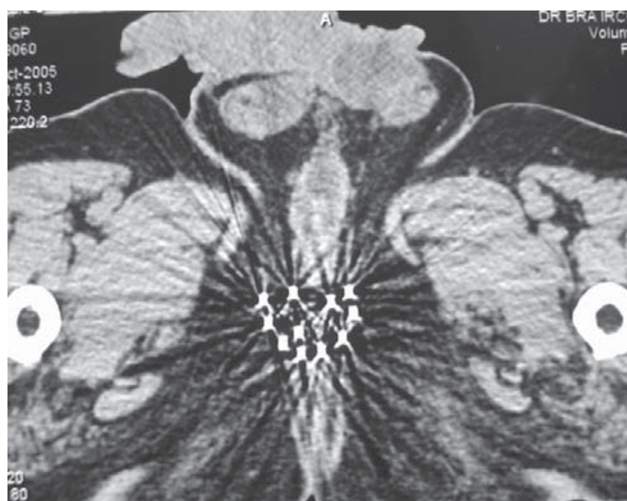

Fig. 1 Axial CT image at the level of prostate showing the final placement of the needles for interstitial brachytherapy. Each needles were individually guided using TRUS.

Suitable candidates for this procedure are patients who have organ-confined prostate cancer or those who have minimal spreading beyond the prostate. This form of therapy is not performed in our institute. First the staging workup is done to assess the disease extent. Cryoablation is performed in localized cancer. Under anesthesia and in lithotomy position, an ultrasound probe is guided into the rectum. The prostate is imaged and its dimensions measured. An aiming grid software program is then activated and images of the prostate are projected on a screen. Under continuous monitoring with ultrasound imaging, cryoablation probes are placed at predetermined sites within the prostate by using a transperineal approach. The freezing starts at the front part of the prostate by activating the front probes, followed by the middle and finally the back probes. This sequence allows continuous monitoring (by visualizing the freezing process through TRUS). Two freezing cycles are usually done. Between them, the prostate is allowed to thaw either passively or actively by using helium gas. If the prostate is more than 26 to 27 mm. long, an apical pullback maneuver is usually done to freeze the lower part of the prostate. Double freezing is performed again[11].

Each of the commercially available cryosurgical systems has a different type of probe and placement strategy, but aim to freeze the prostate, tumor(s) and surrounding tissue — except the urethral area. By keeping the urethra warm during prostate freezing, the urethral wall remains viable, minimizing the risk of urethral damage, obstruction and urinary incontinence. Oral antibiotics are usually given for 10 to 14 days. Other symptoms and signs the patient may experience are generalized fatigue that usually persists for seven to 10 days, urethral discharge, scrotal swelling, numbness at the tip of the penis, passage of flecks of tissue, pain or burning sensation during urination and increased urinary frequency and/or urgency. Urethral injury might cause significant complications. Impotence occurs in about 50% of the patients. Recto-urethral fistula formation is another potential complication.

A PSA test is usually done at three months. Also, a prostatic biopsy may be done at three to six months to assess for prostate destruction and absence of viable cancer cells especially if PSA level is detectable. If the biopsy proves negative, PSA measurements are obtained monthly for one to two years, then every six months for the next one to three years and every year thereafter. Initial success defined as negative biopsy at 3 months occurs in over 89% to 95% [19, 20].The overall negative biopsy rate at 1 to 2 years for patients with localized disease is 82% to 87% [19, 20].

OTHER IMAGE GUIDED THERAPEUTIC PROCEDURES FOR LOCALIZED PROSTATIC MALIGNANCY

All these procedures aim at localized prostatic parenchymal destruction to kill the malignant cells. A staging workup is done in all patients to assess the disease extent. The tumor volume and its spatial geometry are assessed in the preplanning workup[6]. The physical or chemical agent is then introduced under imaging guidance to destroy the parenchyma.

HIFU for prostate cancer is based on the ability of a highly

focused beam of US to deposit a high amount of energy into the tissue thus causing parenchymal destruction. It is carried out under a spinal or general anesthetic[14]. With the patient lying on his left side, an endorectal probe incorporating an ultrasound scanner and a HIFU treatment applicator is inserted. This allows the target area to be monitored and defined before being treated. The probe emits a beam of ultrasound, which is focused to reach a high intensity in the target area. Absorption of the ultrasound energy creates an increase in temperature (between 70ºC and 100ºC), which destroys the tissue within the focal area. A cooling balloon surrounding the probe protects the rectal mucosa from the high temperature. A urethral or suprapubic catheter is used after the procedure. Transurethral resection of the prostate may be carried out immediately before the HIFU treatment, to reduce the volume of the prostate and minimize the amount of necrotic debris left after the HIFU procedure[21].

Radio-frequency ablation for prostatic cancer is performed with the patient being positioned in lithotomy position under anesthesia. The electrodes are introduced via the perineum under TRUS guidance (MRI guidance can also be used) and then the tumor is ablated[22]. As with other methods adjacent tissue, like the rectum or urethra might get involved and lead to rectal wall necrosis, urethral strictures etc.

IMAGE GUIDED ABSCESS DRAINAGE

Prostatic abscess is a relatively uncommon infection found in diabetes, chronic renal failure, conditions of immunosuppression and in those undergoing urethral instrumentation or chronic catheterization. The prostate is usually enlarged, but tenderness and fluctuation are unreliable signs and are seen in less than one-third of cases. Consequently, imaging plays a large part in diagnosis of prostatic abscess. Although treatment includes antibiotics, most cases require drainage. Transurethral incision or resection is currently regarded the best method of draining a prostatic abscess, especially if the abscess is in the peri urethral region[23].

Abscesses may be treated with TRUS guided aspiration and drainage[24] (Fig. 2). With the patient in the lithotomy position, the collection is assessed and needle is introduced under guidance. Because of difficulty removing the probe and needle guide over a guide wire, if a biopsy guide is to be used, a detachable one is preferred. After insertion, the drainage catheter should be taped to the inner aspect of thigh, left to gravity drainage, and flushed every 6 to 8 hours. The patient is put on antibiotics. Removal is appropriate when the patient has defervesced, tube out put is less than 20 ml/ day and the residual potential space has been obliterated on an abscessogram.

IMAGE GUIDED ASPIRATION OF PROSTATIC CYSTS

Prostatic cysts may be of different types- mullerian duct cysts, prostatic utricle, cysts of the prostate, ejaculatory duct cysts- but they cannot be always differentiated on TRUS[24]. Midline periurethral cysts, also known as utricle cysts, are thought to be derived from an incompletely regressed mullerian duct. Ejaculatory duct cysts, derived from Wolffian ducts, typically contain sperm and can be confused with utricle cysts when they appear midline by ultrasound. Prostatic cysts, also known as retention or degenerative cysts are more lateral in location and rarely reach sufficient size to compress the adjacent ejaculatory ducts and cause infertility. These cysts may develop complications- hemorrhage, infection etc. Obstructing cysts are most commonly seen in a periurethral location but can affect the seminal vesicles or the vas deferens. These cysts can cause obstruction of the genital tract leading to infertility.

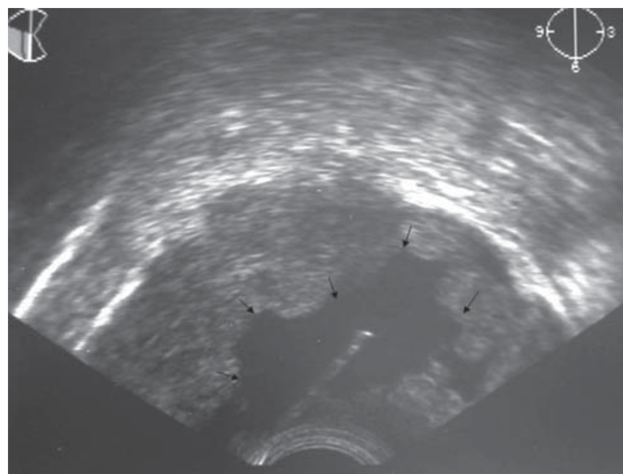

Fig. 2 Prostatic abscess (black arrows) being aspirated by an 18 gauge needle under TRUS guidance.

In some cases, fertility can be restored to patients with cysts that are occluding part of the ductal system by decompression, provided that the ductal system itself is intact [25]. In these cases, ultrasound guided aspiration of the cystic contents is used to relieve the pressure, which can allow the ducts to open and to function normally. TRUS can also be performed to guide aspiration for the relief of discomfort resulting from pressure of these cysts on adjacent structures or for diagnostic purposes if complications occur[24].

CONCLUSION

Majority of the procedures performed on the gland are concerned with the detection and treatment of prostatic malignancy, and are as good as surgical procedure for the treatment of localized malignancy. However these procedures have their own set of complications as described. MR guidance for these therapeutic interventions is gradually becoming more widespread. Newer techniques are being evaluated in comparison with the existing ones. Compared with these procedures for diagnosis/treatment of malignancy,

abscess drainage or cyst aspirations are performed relatively infrequently. With further advances with imaging and newer procedures for tissue ablation, the choice of treatment for prostatic malignancy might change.

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