Prostate Cancer and Robotic Surgery

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ROBOTIC-ASSISTED LAPAROSCOPIC PROSTATECTOMY (RALP) IS CURRENTLY BEING USED BY SEVERAL HOSPITALS IN CANADA TO REMOVE CANCEROUS PROSTATE GLANDS. HOWEVER, ITS BENEFIT THUS FAR HAVE BEEN MINIMAL WHILE COSTS HAVE BEEN HIGH. THIS ARTICLE IS A COMPREHENSIVE REVIEW OF PROSTATE CANCER AS WELL AS AN ASSESSMENT OF PAST AND PRESENT METHODS OF MANAGEMENT.

It is estimated that there will be 20 700 new cases of prostate cancer in Canadian men this year. Prostate cancer accounts for 4 200 deaths and ranks third in cancer mortalities. Given the incidence of prostate cancer, it is helpful to know how it begins, when to seek action, and what surgical options are available (Canadian Cancer Society, 2006).

Anatomy and Physiology

The prostate gland is located inferior to the bladder and anterior to the rectum. The prostate is about the size of a golf ball and is divided into four zones called the transition, central, anterior and peripheral zones (Figure 1). The transition zone surrounds the prostatic urethra, which is a tube that runs from the bladder to allow for urine flow. The peripheral zone is located at the back of the prostate gland and is therefore the closest to the rectum. The peripheral zone also contains most of the secretory glands and is also the most common location of prostate cancer. The prostate capsule is a membrane that surrounds the gland (Grimm et al., 2003).

Prostatic secretions account for approximately a quarter of the volume of semen and help to increase the motility and viability of the sperm. Prostate-specific antigen, also called PSA, is an important proteolytic enzyme. PSA helps to break down the clotting proteins of the seminal vesicles to make the ejaculate more fluid when it enters a woman during sexual intercourse (Tortora et al., 2003).

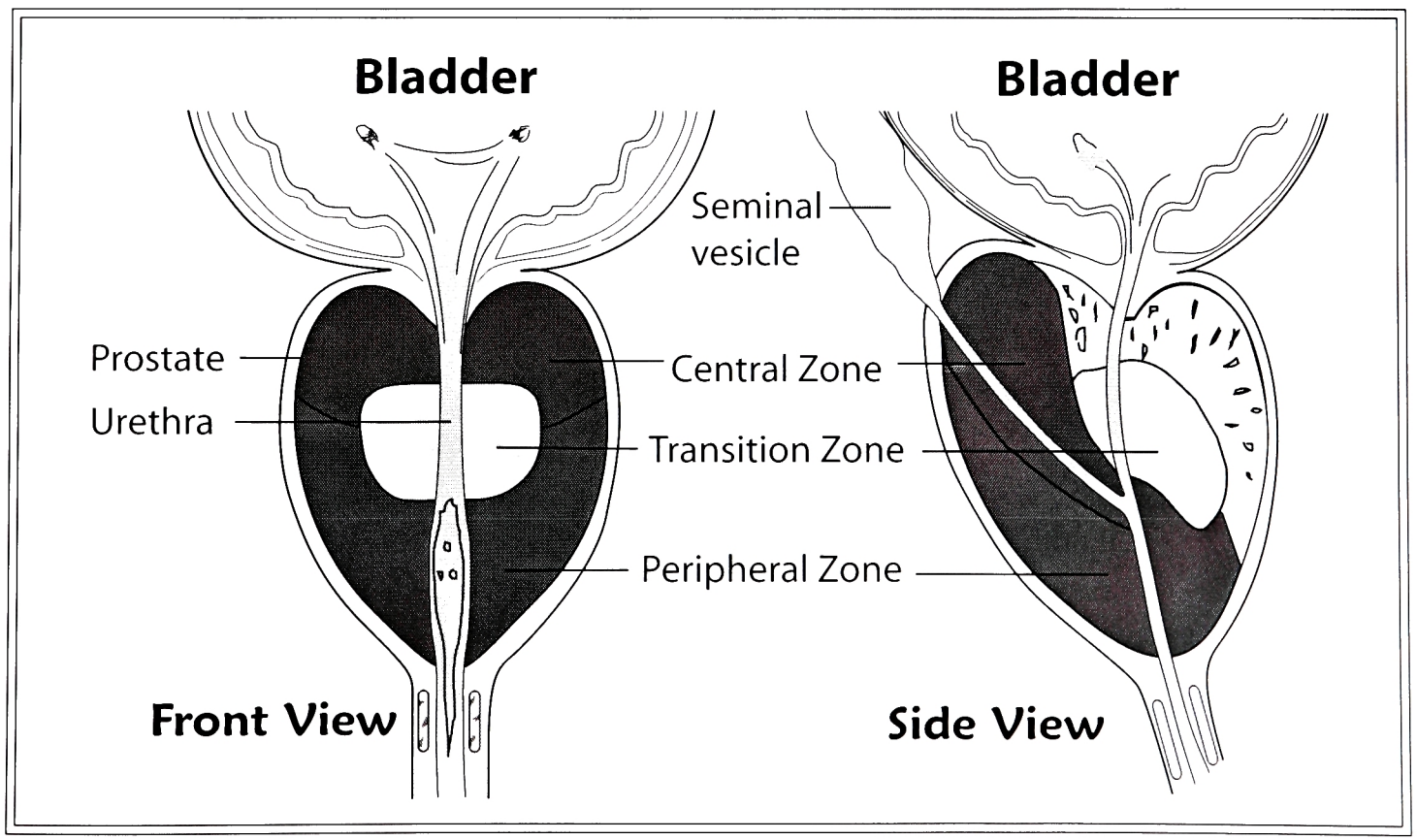

Figure 1: Prostate zones (Prostate Research Campaign UK, 2004).

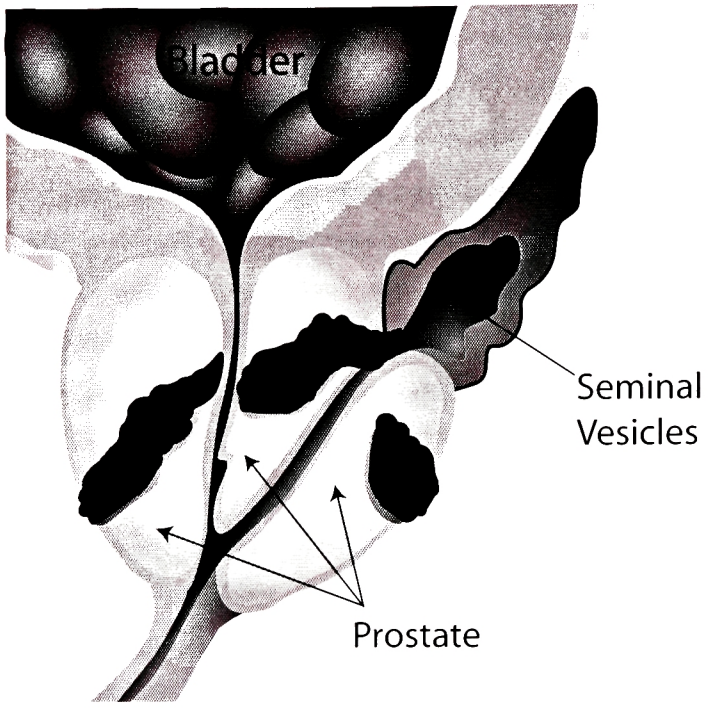

Figure 2: Tumour has penetrated prostatic capsule and may invade seminal vesicles (Oncology Channel, 2005).

What Can Go Wrong?

It is common for the prostate to enlarge with age. In fact, the transition and central zones can grow after the age of forty. Prostate conditions may include benign prostatic hyperplasia (BPH), prostatitis, and prostate cancer. BPH refers to a "non cancerous enlargement of the prostate," which can compress the prostatic urethra and impede urination. Other symptoms may include the sensation of a partially filled bladder or the need to urinate more frequently. Symptoms of prostatitis (inflammation of the prostate) may resemble those of BPH, and can also include fever, perineal pain and painful ejaculations. Prostate cancer is the most serious prostatic disease and refers to the "uncontrolled growth of cells that line the ducts of the prostate gland." Recall that prostate cancer typically occurs in the peripheral zone of the prostate (Grimm et al., 2003).

Risk Factors

Three risk factors for prostate cancer include age, family history and race. Men should get regular prostate tests, as the risk of getting prostate cancer increases with age. The screening process is even more important if an immediate family member also had prostate cancer. African-American men are known to have the highest risk not only of developing prostate cancer, but also of its emergence earlier in life. There is no conclusive study to illustrate why African-American men are at higher risk, but speculation includes socioeconomic factors, diet and genetics (American Cancer Society, 2006). A number of substances can promote the growth of prostate cancer such as testosterone and human growth factors. Laboratory tests indicate that adults who rapidly gain weight start secreting higher levels of growth factors, which can induce prostate cancer growth. African-American men are known to have higher testosterone levels, especially before the age of forty, compared to other ethnic groups (Grimm et al., 2003).

Screening Tests

Although most men should start getting screened from the age of fifty onwards, African-American men, and individuals with a family history of prostate cancer, should start being screened around the age of forty-five. The two main screening tools include the digital rectal exam (DRE) and the measurement of free serum PSA. The DRE involves the doctor placing a gloved finger into the rectum to check for physical irregularities of the prostate, however, these do not always indicate the presence of prostate cancer (CDC, 2006).

The PSA test may be more useful than the DRE because it can be hard to find nodules. PSA levels are measured according to nanograms (ng) per milliliter (mL) of serum. It is normal for some PSA to enter the bloodstream. The normal upper limit was considered to be 4.0 ng/mL but recent evidence suggests that normal levels for younger men should be between 2.5 – 3.0 ng/mL. Elevated PSA levels may indicate cancer, but can also include other non-cancerous conditions such as benign prostate hyperplasia, inflammation, and infection. A biopsy of the prostate is another method of screening for cancer, which involves using a needle to obtain samples of prostatic tissue for analysis (Grimm et al., 2003).

Cancer Growth and Spread

When discussing prostate cancer, it is assumed that the term refers to adenocarcinomas, which are cancers that arise from secretory cells of certain organs (Figure 2). In this case, adenocarcinomas come from the ducts of the prostate gland. Two rare forms of prostatic cancers include urothelial cell carcinomas (UCC), which are derived from cells that line the bladder and urethra. The second type of a rare prostatic cancer is known as a sarcoma, which arises from the prostate's muscular and connective tissue (Grimm et al., 2003).

Fortunately, prostate cancer usually grows slowly, but like other cancers, it may grow and spread at a fast rate. If it does spread, it does so via the blood and lymphatic systems. There are three ways to assess the growth rate of prostate cancer. First, one can measure the PSA velocity, which refers to how fast the PSA levels are rising. PSA velocities are age-specific and race-specific. If PSA levels rise at more than 0.75 ng/mL in under one year, further investigation is needed. Second, one can measure the Gleason grades, which are the most common way of assessing the severity of prostate cancer (Prostate Cancer Research Foundation, 2005). Third, physical examinations and radiological tools such as MRI and bone scans can help to analyze the spread of the cancer (Grimm et al., 2003).

Where Does Prostate Cancer Spread?

Prostate cancer can penetrate the prostate capsule and can even move into the seminal vesicles. Cancer cells can spread into the pelvic region by entering lymph nodes in the pelvis. Prostate cancer cells have an affinity for growing in bones, usually in the spine, pelvis, or long bones such as the femur and humerus (Tewari et al., 2004).

Treatment and Technology

Open (non-robotic) surgical procedures include the retropubic approach, where an incision is made in the abdomen, and the perineal approach, where an incision is made between the scrotum and anus. The purpose of both procedures is to remove the prostate, which is referred to as a prostatectomy. Pure laparoscopic radical prostatectomy involves removal of the prostate gland, seminal vesicles and lymph nodules through small abdominal incisions. It is only performed in a few centres around the world because of its technical challenges, including St. Joseph's Hospital in Hamilton, Ontario (Dr. Matsumoto, personal communication, January 9, 2007). Robotic-assisted laparascopic prostatectomy (RALP) has the same goal as open surgery and the pure laparoscopic approach – the removal of the prostate gland (M.D. News, 2006). However, the main advantage of RALP is that it can overcome some of the steep learning curves associated with laparoscopic radical prostatectomy (Dr. Matsumoto, personal communication, January 9, 2007).

Overview of Technology

The Intuitive Surgical's "da Vinci Surgical System" is an exciting new development. The da Vinci Surgical System is another step forward in the field of minimally invasive surgery. The system consists of a console and a patient-side robotic system. The surgeon sits at the console, which has a screen that provides a full 3D view of the operative field. The surgeon uses the controls at the console, which translate hand motions into robotic motions, carried out by four robotic arms (Figure 3). The robotic arms are equipped with "Endowrist technology," which are instruments that can move like human wrists (Intuitive Surgical, 2005).

Procedure Description

RALP using the da Vinci Surgical System consists of making five ports (or entry points) in the patient's abdomen. Four of the ports are used to allow the four robotic arms to enter the patient's body and the last port is used for the camera for visualization at the surgeon's console.

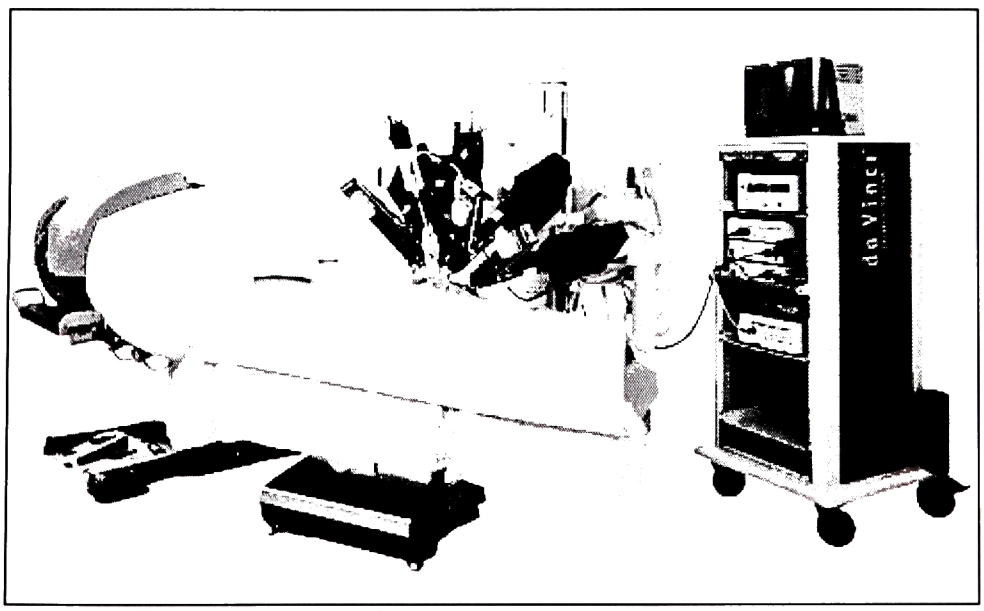

Figure 3: The da Vinci Surgical System with surgeon console at left and patient in middle (Hatton Institute, 2005).

The camera's magnification capability improves the surgeon's view of the operative field (Hoznek et al., 2003). Just like open surgery, the prostate, seminal vesicles and lymph nodes are assessed in order to determine the spread of cancer, (Intuitive Surgical, 2005).

RALP follows the same surgical principles as radical retropubic prostatectomy (RRP). The prostate is separated from the bladder neck and the seminal vesicles are removed. The pedicles (prostatic arteries) are the main blood supply to the prostate and are closed with clips to prevent bleeding. A vesicouretral anastomosis (between bladder neck and urethra) takes place and is the most challenging part of the surgery (Ong et al., 2004). The prostate is placed in an entrapment bag when using RALP, and then an umbilical incision is enlarged to accommodate removal of prostate with the robotic arm. Finally, the pneumoperitoneum (filling of the abdomen with an inert gas to tamponade blood vessels) is released and the sites where the robotic arms entered the patient are closed.

Outcomes and Advantages

There are debates with regard to whether RALP is superior to RRP partly because there are not many balanced prospective studies to make an adequate comparison (Bhayani et al., 2004). RRP is not associated with a lot of post-operative pain nor does it require large incisions. RALP is supposed to offer less pain and less scarring in the post-operative period, which raises the question as to whether the marginal improvements using the da Vinci system are worth the cost of the system and the extra training (Webster et al., 2005). The use of the da Vinci Surgical System may include improvements in certain outcomes. There is emerging evidence that intraoperative bleeding may be lower using RALP because of the establishment of a pneumoperitoneum and the precision of the robotic arms. Less bleeding in the surgical area contributes to an improved and clearer operative field for the surgeon (M.D. News, 2006). Lastly, the duration

of hospital stay between RRP and RALP patients is almost identical (Tewari et al., 2003). Few centres in the U.S. actually profit from using the da Vinci system because of the high cost of the technology. Pure laparascopic surgery is probably more cost-effective than open and RALP approaches (Dr. Matsumoto, personal communication, January 9, 2007).

Functional Outcomes

Prostate cancer patients will most likely deal with urinary incontinence and erectile dysfunction after surgery. The evidence is mixed as to whether RALP improves a patient's return to continence. The reasoning is that an excellent visualization of the operative field combined with the precision of the da Vinci Surgical System allows surgeons to meticulously remove the prostate without injuring neighbouring musculature (Mennon et al., 2004).

The cavernous nerves, located within the neurovascular bundle, are the nerves that control erectile function. Once again, no published results indicate whether RALP is better than RRP in preserving erectile function outcomes after surgery. However, the technology for the da Vinci System keeps advancing. For example, Endowrist scissors with electrocautery capability have been produced to minimize the number of instrument exchanges. Furthermore, the use of ultrasound and electrical stimulation devices may assist in locating and avoiding damage to cavernous nerves, to minimize a decline in erectile function (Intuitive Surgical, 2005).

Conclusion

The prostate gland is responsible for promoting the viability and motility of sperm and the most serious form of prostatic disease is prostate cancer. Technological advances, such as the da Vinci Surgical System, may help urologists overcome the technical challenges of laparoscopic radical prostatectomy and may offer improved outcomes for patients, especially in terms of incontinence and potency. Despite a lack of studies to substantiate claims that the da Vinci System definitely offers better surgical outcomes, current literature discusses potential benefits of RALP in terms of technological advancements.

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