Medical Imaging and Infertility

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After completing this article, the reader should be able to:

- Identify infertility incidence and risk factors.
- Describe typical male and female reproductive anatomy and physiology.
- Explain conception and implantation.
- Summarize the most common causes of infertility in men and women.
- Discuss common medical imaging procedures used to diagnose infertility.
- Identify common interventions used to treat infertility.

Many couples face infertility, and even with medical advances, infertility is not always solved easily. Infertile couples are defined as those who are unable to conceive after one year of frequent, unprotected sex. The causes of infertility in men and women vary widely, and medical imaging typically plays a role in their diagnosis and treatment. Practitioners must investigate anatomic causes when investigating infertility in a couple, and imaging findings help direct patient care. Therefore, the appropriate selection of imaging modalities to visualize accurately various anatomic causes of infertility is essential.

A primary concern for the healthcare team is the effect of infertility on the psychological and social well-being of couples. Radiologic technologists should understand infertility, as well as the emotional and physical difficulties that patients face. Furthermore, understanding reproductive structure and function in both sexes, as they contribute to overall reproductive success, is essential for radiologic technologists performing these procedures.

Incidence and Risk Factors

Although many diseases are investigated with medical imaging when a patient experiences signs and symptoms, with infertility, this is not necessarily the case. The inability to get pregnant is the main sign of infertility, and most couples are not aware of problems until they begin trying to conceive. In the United States, an estimated 10% to 15% of couples are infertile. Infertility can be a result of a single condition in the man or woman, or a combination of factors preventing a pregnancy from occurring or continuing. For example, women might have absent or irregular menstrual periods. Changes in hair growth, sexual function, or ejaculation can be signs of hormonal problems in men. Other signs of male infertility include small testicles or scrotal swelling.

Risk factors associated with infertility for both sexes include age, tobacco use, alcohol use, weight, and physical...
activity. In women, reproductive history, demographics, and lifestyle habits also have been associated with reduced fertility. In men, other risk factors include history of infection or inflammation, testicular trauma, undescended testicles, and exposure of genitals to high temperatures. Many of these influencing factors need more study.

Age plays a primary role in women’s fertility. Younger couples have better success rates because of many factors. For example, women are born with a finite number of eggs, and they reach their fertile peak between ages 23 and 31. Men produce sperm throughout their lives, but the quality of sperm declines with age. If the male partner is over the age of 45, it can take a couple 5 times longer to conceive.

Couples should see an infertility specialist if the woman is younger than 35 years and unable to get pregnant after a year of trying to conceive or older than 35 years and unable to conceive after 6 months of trying.

Avoiding drug and alcohol use and maintaining a healthy lifestyle also play a role in fertility. Smoking can increase the risk of miscarriage, and in men, it increases risk of erectile dysfunction and low sperm count. Fertility can improve when a person quits smoking, and the rate of pregnancy complications declines. Alcohol use can make becoming pregnant more difficult and decrease sperm count and motility.

Eating healthy and staying active is important for both partners. Lack of physical activity contributes to obesity, and an inactive lifestyle might increase infertility. Overweight men might have problems with sperm count and hormone levels. In contrast, underweight women with anorexia or bulimia are at risk for fertility disorders, and women who exercise intensely could have problems with ovulation.

**Female Reproductive Anatomy**

The function of the female reproductive system is to generate the ovum (egg), transport it to where it can be fertilized, and nourish the embryo and fetus. In addition, the female reproductive system produces female sex hormones known as estrogen and progesterone. The female reproductive system consists of the ovaries, fallopian tubes, uterus, and vagina (see Figure 1).

The female gonads, or primary reproductive organs, are the paired ovaries. Located on each side of the uterus, they are held in place by peritoneal ligaments. The ovaries are similar to an almond in size and shape. Main ovarian functions include oogenesis (egg production) and secretion of hormones, including estrogen, progesterone, and small amounts of male hormones.

The fallopian tubes, sometimes referred to as the oviducts, are located on each side of the uterus. They are the site of normal fertilization and transport the ovum to the uterus for implantation. A typical fallopian tube has a length of approximately 10 cm to 12 cm and a 1-mm to 4-mm luminal diameter. Each fallopian tube has 3 parts: the isthmus, ampulla, and infundibulum. The short segment near the uterus is the isthmus; the longer region involving most of the tube is the ampulla, and the flared infundibulum is located at the terminal end. The fallopian tubes open into the peritoneal cavity and do not connect directly to the ovaries. Fingerlike projections called fimbriae assist in sweeping an ovulated egg into the fallopian tube.

The uterus is a pear-shaped organ located posterior and superior to the urinary bladder. Its main portions include the fundus, body, isthmus, and cervix. The fundus is the most superior, bluntly rounded portion. The
body is the main portion, which narrows as it extends from the fundus to the isthmus. The constricted region between the cervix and body is called the isthmus. The cervix is the narrow, most inferior portion of the uterus. The vagina is attached around its circumference.¹³

The uterine wall consists of the perimetrium, myometrium, and endometrium. The inner endometrium can be further divided into the stratum functionale and stratum basale. The stratum functionale is sloughed off during monthly menstruation. The stratum basale enables the stratum functionale to rebuild after menstruation occurs.¹³

The vagina extends from the cervix to the outside of the body. The vaginal opening is located between the rectum and urethra. It serves as the female copulatory organ and the birth canal.

The vulva contains many accessory structures. The most anterior aspect is called the mons pubis, which is a skin-covered fat pad located over the symphysis pubis. Extending from the mons pubis downward is the labia majora. The labia minora are smaller folds of skin on either side of the vaginal opening. The clitoris is the female’s erectile tissue and extends from the anterior junction of the labia minora. The urethral orifice is anterior to the vaginal orifice. The pararectal glands secrete mucus and are located on each side of the urethral orifice.¹³ On either side of the vaginal orifice are the ducts of the Bartholin glands, also called the greater vestibular glands. These glands secrete a mucus-like lubricating fluid. Finally, the region between the vaginal orifice and anus is called the perineum (see Figure 2).¹³

**Oogenesis and Ovulation**

The production of the female sex cells is called oogenesis. An ovum contains 23 chromosomes and is designed uniquely to provide nutrients for rapid embryo development. At birth, girls have approximately 1 million immature sex cells called oocytes. Each of these oocytes is contained in an ovarian follicle. By the time a girl reaches puberty, the number of oocytes has decreased to just around 400 000.¹³ At this age, the ovarian follicles are referred to as primary follicles, each containing an oocyte surrounded by granulosa cells. Typically, 350 to 500 of the primary follicles will develop into mature follicles during a woman’s reproductive lifetime.⁵

As an ovarian follicle matures, it moves closer to the ovary wall and becomes a fluid-filled bulge at the surface. Usually, only one follicle matures each month. Others might develop but deteriorate.¹⁶ As the follicle matures, the granulosa cell layer surrounding the oocyte increases, and an antrum, or hollow chamber, develops.⁵ The mature follicle also is known as a graafian follicle; it releases an ovum upon ovulation. The ruptured follicle becomes a hormone-secreting gland known as the corpus luteum, which decays in 12 to 14 days if the egg is not fertilized (see Figure 3).⁵

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**Figure 2. Female external genitalia. © 2016 ASRT.**
Male Reproductive Anatomy

The function of the male reproductive system is to produce, sustain, and transport sperm. In addition, the male reproductive system produces androgens, or male sex hormones. Male reproductive anatomy consists of the testes, scrotum, genital tract, and penis (see Figure 4).

The male gonads, or primary reproductive organs, are the paired testicles where the production of male sex cells occurs. During fetal development, the testes are located high in the abdominal cavity. They descend into the scrotum during the last 2 months of development or shortly after birth.\(^1\) The scrotum surrounds each testis, the epididymis, inferior portion of the vas deferens, and the beginning portion of the spermatic cord. Its 2 sacs are divided by a septum. The scrotum is suspended from the groin.\(^2\) With the testes in the scrotum outside the body, they are kept approximately 3° F lower than normal body temperature, which is essential for viable sperm production.\(^3\) Each testicle has an estimated 250 lobules that contain 1 to 4 seminiferous tubules. Spermatogenesis occurs in the seminiferous tubules, and from there, the sperm enter the epididymis where they mature and become fertile.\(^4\)

The male genital tract begins at the epididymis and includes the vas deferens, ejaculatory duct, and urethra. Important accessory glands that secrete into the genital tract include the seminal vesicles, prostate, and bulbourethral glands.\(^5\) The epididymis is a large coiled tube located on the superoposterior aspect of each testicle, which serves as a temporary storage site for sperm. Sperm...
mature and become fertile before entering the vas deferens.

The vas deferens, or ductus deferens, is continuous with the epididymis. It conveys sperm to the ejaculatory duct. The thick and muscular vas deferens is palpable through the scrotal wall, and with its connective tissue sheath, it forms the spermatic cord, which passes through the inguinal canal into the abdominal cavity.\(^5\)

The seminal vesicles are paired glands that produce a sugar-rich fluid, providing sperm with a source of energy and motility. This energy and motility is necessary for sperm to travel deep into the female genital tract to meet the ovum. Secretions from the seminal vesicles make up the majority of a man’s ejaculatory fluid. The seminal vesicles join the vas deferens at the ejaculatory duct.\(^5\)

The ejaculatory duct passes through the prostate gland, which is located below the urinary bladder. The prostate gland secretes a milky alkaline substance, which also enhances sperm motility, and empties into the portion of the urethra that runs through the gland.\(^13\)

In men, the urethra is part of the urinary and reproductive tracts. It has 3 portions: the prostatic urethra, membranous urethra, and penile or spongy urethra. The prostatic urethra is the most superior portion and passes through the prostate gland. The membranous urethra is a short segment that passes through the floor of the pelvis. The longest portion is the penile or spongy portion, which extends the length of the penis and ends at the urethral orifice.

The final secretion in the male duct system comes from the bulbourethral glands. These glands are located near the base of the penis and become stimulated with sexual arousal. The alkaline, mucus-like fluid helps to neutralize the acidity of urine residue in the male urethra. It also helps reduce the acidity of the female vagina and provides lubrication for the tip of the penis.\(^13\)

In men, the external genitalia consist of the penis and scrotum. The penis is the male copulatory organ, located superior to the scrotum and inferior to the umbilicus. The shaft of the penis contains 3 columns of erectile tissue. The 2 dorsal columns are called corpus cavernosa, and the corpus spongiosum surrounds the penile urethra.\(^13\) The penis shaft ends at an enlarged region termed the glans (see Figure 5).

**Spermatogenesis and Ejaculation**

Spermatogenesis refers to the production of the male sex cells. From puberty forward, the seminiferous tubules continuously produce sperm. Most men produce a significant number of sperm each day throughout their lives, although with increasing age that number decreases.\(^4\)

A normal sperm cell contains 23 chromosomes and has 3 parts: a head, midpiece, and tail. The head contains the man’s genetic material in the nucleus of the cell. It is covered by an acrosome, which contains enzymes enabling the sperm to penetrate and fertilize

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**Figure 5.** Sagittal section of the penis illustrating the urethra exiting the bladder, passing through the prostate gland, and entering the penis. © 2016 ASRT.
Hormones

In addition to normal function of the reproductive systems, the endocrine system also plays a vital role in fertility. Hormones help our bodies maintain homeostasis. They also contribute to differences in body functions, such as reproduction and development.\(^5\) Puberty in boys and girls begins when the hypothalamus starts to secrete gonadotropin-releasing hormone to the anterior pituitary gland.\(^13\) Luteinizing hormone and follicle-stimulating hormone are secreted by the anterior portion of the pituitary gland. Hormonal control of sperm production involves gonadotropin-releasing hormone, follicle-stimulating hormone, luteinizing hormone, and testosterone.\(^17\) In women, gonadotropin-releasing hormone, follicle-stimulating hormone, luteinizing hormone, estrogen, and progesterone play vital roles in ovulation and normal menstruation cycles. The hormones in men and women work jointly to prepare the reproductive organs for procreation.

Luteinizing hormone promotes growth of interstitial cells in the testes and stimulates secretion of testosterone in men. Luteinizing hormone also affects the ovaries, the uterus, and menstruation in women.\(^13\) It stimulates the ovarian follicles to mature, triggers ovulation, and stimulates the development of the corpus luteum. It also stimulates secretion of estrogen in women.\(^5\) Follicle-stimulating hormone affects the testes and ovaries. It stimulates the seminiferous tubules to grow and produce sperm and the ovarian follicles to develop. It also stimulates estrogen and progesterone secretion in women.\(^5\)

The ovaries secrete estrogen and progesterone. Estrogen is responsible for the development of the female reproductive organs, the appearance of pubic hair, breast development, and female body habitus. Growth of epithelial cells that line the uterus is stimulated by estrogen and, along with progesterone, is responsible for initiation of the first menstrual cycle, or menarche.\(^4\) Progesterone stimulates the proliferation and vascularization of the epithelial lining of the uterus. The corpus luteum also produces progesterone, promoting conditions required for a viable pregnancy.\(^5\)

The testes secrete testosterone, which works with follicle-stimulating hormone to promote

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**Figure 6.** Mature sperm cell with enlarged illustration of the sperm head and midpiece. © 2016 ASRT.
spermatogenesis. In addition, it promotes the development and maintenance of male sex characteristics. Testosterone also stimulates secondary sex characteristics, such as a deepened voice and increased muscular development.

**Female Reproductive Cycles**

Two sequential cycles occur in women each month to prepare for pregnancy: the ovarian cycle and the uterine cycle. The average monthly cycle length is 28 days; however, the length can vary from woman to woman. Abnormal monthly cycles can contribute to infertility, and it is important for women who want to conceive to be familiar with their cycles.

The ovarian cycle, in which the follicle develops, includes 3 phases: follicular, ovulatory, and luteal. The follicular phase occurs during cycle days 1 through 13. During this phase, follicle-stimulating hormone from the pituitary gland stimulates the growth of the ovarian follicles. Estrogen secretion increases during this time, and the follicles continue to grow until the middle of the cycle. Ovulation usually occurs on day 14 of the cycle. The follicle ruptures as a result of high estrogen levels. This, in turn, causes a surge in luteinizing hormone. Finally, the luteal phase occurs during days 15 through 28. High luteinizing hormone levels stimulate a corpus luteum to develop from the ruptured follicle. The corpus luteum is a temporary endocrine structure that decays if the egg is not fertilized. If the egg is fertilized, it secretes the progesterone and estrogen required for a viable pregnancy.

The uterine, or menstrual, cycle involves changes that occur in the stratum functionale of the uterus due to fluctuations in progesterone and estrogen levels during the ovarian cycle. The menstrual phase takes place during days 1 through 7. Day 1 is the first day of bleeding, and it typically continues for 3 to 5 days. The stratum functionale detaches from the uterine wall and passes through the vagina as menstrual flow. New follicles begin growing in the ovary at the same time. The proliferative phase begins with the end of the menstrual phase and occurs during days 8 through 14. During this phase, the endometrium is repaired and continues to thicken. An increase in estrogen from growing follicles facilitates this. Ovulation marks the end of this phase. Finally, a secretory phase occurs simultaneously with the luteal phase of the ovarian cycle during days 15 through 28. Continued thickening of the endometrium is stimulated by progesterone from the corpus luteum. If fertilization does not occur, menstruation begins again and the cycle continues.

**Fertilization and Implantation**

Fertilization typically occurs when a discharged ovum with 23 chromosomes unites with a sperm cell also containing 23 chromosomes. Fertilization typically takes place in the portion of the fallopian tube closer to the ovary, and sperm cells must travel through the uterus to meet the ovum there. The fertilized ovum then migrates to the uterus and implantation occurs.

A fertilized ovum is called a zygote. Typically, a zygote consists of 46 chromosomes, 23 from the sperm cell and 23 from the egg cell. After fertilization occurs, the zygote divides rapidly into a solid cell mass called a morula. The cell mass continues to divide on its journey to the uterus until it forms a blastocyst, a hollow ball of cells that eventually implants into the uterine lining.

The layer of cells surrounding the blastocyst is called the trophoblast. The trophoblast produces human chorionic gonadotropin hormone and later becomes a portion of the placenta. Human chorionic gonadotropin usually is present in urine about the same time as a missed period and can be detected on a home pregnancy test. This hormone, along with progesterone, promotes the conditions required for a viable pregnancy. The inner cell mass of the blastocyst becomes the embryo.

By the seventh day after fertilization (approximately day 21 of the woman’s cycle), the endometrium is ready to receive the blastocyst. As implantation begins, the inner cell mass is near the uterine lining. Enzymes are secreted by the trophoblast cells, producing a hole into which the blastocyst burrows. Implantation is complete when endometrial cells completely grow over the blastocyst. The time between fertilization and implantation is approximately 10 days, with implantation being completed by the fourteenth day following ovulation (see Figure 7).

The probability of achieving pregnancy is 20% to 25% per reproductive cycle in healthy young couples. With fertility-focused sexual activity, 60% will conceive...
Figure 7. Ovulation, fertilization, mitotic division, and implantation. © 2016 ASRT.

within the first 6 months, 84% within the first year, and 92% by the second year.17

Causes of Female Infertility

Female infertility has multifactorial etiology and is quite complex.18 Female infertility occurs in approximately 37% of all infertile couples.19 Congenital or acquired uterine anomalies, postinfectious tubal damage, and endometriosis are the primary female anatomical causes of infertility.20 Ovulation disorders also can contribute to a woman’s inability to conceive. Ovulation disorders account for more than half of female infertility occurrences, whereas tubal damage accounts for 18%.19,21

Uterine anomalies can be congenital or acquired. In 10% of women, uterine cavity abnormalities can be a contributing cause of subfertility (reduced fertility).21 Congenital anomalies of the uterus, such as a septate uterus, can lead to infertility. A septate uterus is divided interiorly by a longitudinal septum. Acquired diseases of the uterus, such as myomas or synechiae (intrauterine adhesions), also can lead to infertility, pregnancy loss, and other obstetric complications.20 Uterine anomalies also might increase the risk of sterility and miscarriage.22

The causes of fallopian tube damage can be intrinsic or extrinsic. An example of an intrinsic cause is ascending salpingitis, which is an infection of the fallopian tube that has traveled upward from the vagina. Peritonitis, endometriosis, and pelvic surgery are extrinsic causes.21 The most common cause of tubal damage is pelvic inflammatory disease (PID).20

Patients with PID have an infection of the reproductive organs, a common complication of sexually transmitted diseases. Chlamydia trachomatis, Neisseria gonorrhoeae, and multibacterial infections are the most common causes of PID.21 Studies have demonstrated a direct relationship between tubal damage severity and serum chlamydia antibody IgG titer.21 A hydrosalpinx or pyosalpinx—types of blocked fallopian tubes—also can result from dilatation secondary to obstruction caused by an infection or adhesion in the tube.18

Changes in the uterine lining or ovulation also can contribute to a woman’s inability to conceive. Endometriosis commonly affects women of reproductive age and can cause pain and infertility.20 It also causes severe pelvic soft tissue inflammation similar to PID resulting in pelvic adhesions that can be well demonstrated with ultrasonography.18

In general, the causes of ovulation disorders can be hormonal or linked to the ovary itself.21 Polycystic ovarian syndrome also might affect ovulation. Polycystic ovaries are one of the most common causes of female infertility.18 Patients with polycystic ovarian syndrome have hormonal imbalances due to complex changes in
the hypothalamus, pituitary gland, and ovaries. These hormonal changes affect ovulation. The ovarian follicles might grow each month, but ovulation might not occur. The many fluid-filled follicles form cysts in the ovary.³³

### Infertility Evaluation

When a couple presents with infertility, the woman generally is evaluated by a gynecologist, and a semen analysis is ordered for the man. Male infertility is suspected if the semen analysis results are abnormal.²⁷ The initial workup includes medical history and physical examination, as well as endocrine system and genetic evaluation in some cases.²⁷ Further evaluation might include diagnostic imaging procedures for both partners. In addition, interventional procedures can be performed to treat common causes of infertility in men and women.

### Diagnostic Imaging for Women

In association with an increase in assisted reproduction procedures, female infertility imaging services also have risen. These include hysterosalpingography (HSG), hysterographic ultrasonography, pelvic ultrasonography, and pelvic magnetic resonance (MR) imaging.² Thirty potential causes of female infertility exist. Because different anatomical structures might be involved, imaging plays an important role in diagnosis. Structures evaluated during the diagnostic workup include the genital tract, ovaries, and peritoneum.² Two-dimensional transvaginal ultrasonography often detects congenital abnormalities, but final characterization and diagnosis usually is obtained with HSG,²² which predominantly is used in the evaluation of infertility.²⁴ Ultrasonography primarily is used for endometrial evaluation and pregnancy, whereas MR imaging primarily is used to evaluate the ovaries and uterine myometrium.²⁴

### Hysterosalpingography

In most cases, diagnostic imaging evaluation for women begins with HSG.²³ The procedure commonly is used to diagnose structural or functional defects in patients with a history of infertility.²³ The use of HSG has increased dramatically as a result of advances in reproductive medicine, the trend of women delaying pregnancy until later in their lives, and more successful in vitro fertilization procedures.²⁴

HSG best demonstrates the patency of the fallopian tubes as well as the uterine cavity. Because fertilization typically takes place in the fallopian tube, it might be inhibited by a blockage in one or both tubes.²⁵ The most common cause of female infertility not associated with ovulation is tubal occlusion; therefore, imaging evaluation begins with HSG to evaluate fallopian tube patency.²³

### Contraindications

Contraindications to HSG include pregnancy, active menstrual bleeding, and PID. To avoid potential pregnancy, patients are instructed to abstain from sex from the time menstrual bleeding ends until the day of the examination.²⁴ Radiation exposure and the injection of contrast media into the uterine cavity are detrimental to an early pregnancy; therefore, patients are scheduled toward the end of their period. The first day of the patient’s last menstrual period must be obtained before the procedure. Radiologic technologists are familiar with the 10-day rule, which emphasizes performing radiologic examinations during the first 10 days following the onset of menstruation.²⁶ Days 7 through 10 are ideal because there is no longer active bleeding, and the risk of ovulation and conception are low. In addition, a thin endometrium during this time results in easier image interpretation.²⁷ Days 11 through 28 generally are avoided because ovulation might have occurred.²⁸ The risk of infection as a result of the procedure is high in patients with PID, and the referring physician might treat patients with a history of PID with prophylactic antibiotic treatment.²⁴

### Patient Preparation

Hospitalization and premedication typically are not necessary for HSG because of the relatively minor instrumentation required for the administration of the contrast medium.²⁹ Although no preparation is required, patients should empty their urinary bladder before the examination. A complete allergy history should be obtained, and if necessary, a contrast allergy preparation can be prescribed. Elective premedication regimens have been proposed to reduce the severity and frequency of contrast
media reactions. Corticosteroids, such as prednisone and methylprednisolone, and antihistamines, such as diphenhydramine, are most commonly administered prophylactically for patients at risk.

A frequently used regimen is a combination of prednisone and diphenhydramine (Benadryl). A 50 mg dose of prednisone is taken orally 13 hours and 7 hours before contrast media administration. In addition, 1 hour before the contrast media administration another 50-mg dose of prednisone and 50 mg of diphenhydramine is taken orally. A nonsteroidal anti-inflammatory drug such as ibuprofen might also be taken 1 hour before the procedure to help reduce cramping caused by the contrast media injection into the uterus and fallopian tubes. Each patient’s experience is different. Some might experience little to no cramping, whereas others experience excruciating pain. Pathology and fallopian tube patency also might play a role in the patient’s pain level and tolerance. Some cramping usually is experienced by patients when the catheter balloon is inflated. Cramping also can occur when the uterus is well distended and is more common with tubal obstruction.

Because contrast has the potential to enter the peritoneal cavity with patent fallopian tubes, a nonionic, low-osmolality, water-soluble contrast medium is preferred for HSG. These agents are supplied as nonsalt forms such as iohexol (Omnipaque), iopamidol (Isovue), ioversol (Optiray), and metrizamide (Amipaque). Nonionic, low-osmolality contrast media contain 3 iodine atoms per molecule and do not dissociate in a solution; therefore, the risk for adverse effects is low. These agents are referred to as ratio-3.0 media.

Procedure

HSG generally is performed in a fluoroscopy room. The erect foot board must be removed from the table. Stirrups can be used to assist the patient into the lithotomy position.

A sterile HSG tray typically consists of a radiopaque speculum, sponge holding forceps, dilator, tenaculum, cannula or balloon catheter, and syringe (see Figure 8). The speculum is used to expose the cervical os. The tenaculum is an instrument used to hold the cervix in place. An antiseptic solution is used to clean the cervical os before catheter placement.

Catheter placement and contrast medium injection usually is performed by a gynecologist. A scout image of the pelvis might be obtained with the patient lying in the supine position before catheter placement and contrast injection. Using aseptic technique, a speculum is placed into the vaginal canal to expose the cervical os. Forceps grasping cotton balls soaked in antiseptic solution are used to cleanse the vaginal walls and cervix. The physician inserts a uterine cannula through the canal of the cervix. An acorn-shaped rubber plug might be used because it fits firmly against the cervical os, or a balloon catheter might be used. To prevent reflux of the contrast medium into the vagina, counter pressure is applied with the tenaculum. Once the uterine cannula and assisting instruments are securely in place, the speculum is removed.

While the radiologist performs fluoroscopy, the attending physician slowly injects the contrast medium. Single anteroposterior projections can be taken at the end of each fractional injection. Oblique, axial, or lateral projections also might be indicated. The pelvic region should be centered on the radiograph, extending 2 inches above the symphysis pubis. All contrast media should be visible, and images should demonstrate a short-scale, high contrast. Images after contrast administration generally include early filling of the uterine cavity, complete filling of the uterine cavity, fallopian tube outlines, and contrast spillage into the abdominal cavity. The radiologist and gynecologist evaluate the images and

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**Figure 8.** Sterile surgical tray for hysterosalpingography (HSG). Image courtesy of Samia Long, AS, R.T.(R).
come to a consensus on diagnosis. HSG can reveal findings suggestive of polyps, adhesions, uterine fibroids, septa, and crucial information about fallopian tube patency and contour (see Figure 9).\textsuperscript{29}

Fallopian tubes should appear as thin lines with a smooth appearance and a widening ampullary portion.\textsuperscript{21} If tubal abnormalities are observed, they could be due to spasm, occlusion, or infection. Tubal abnormalities also can be congenital. If contrast does not spill into the abdominal cavity or distribute freely, peritubal adhesions could be the cause of tubal abnormalities.\textsuperscript{26} The typical uterus should present as a well-defined inverted triangle with smooth contours (see Figure 10).\textsuperscript{24}

Abnormal uterine findings, such as endometrial polyps and fibroids, are reported in as many as 50% of infertile women. During HSG, these findings are observed as filling defects or uterine wall irregularities. Intrauterine adhesions and congenital abnormalities also can be demonstrated.\textsuperscript{21} Other abnormal findings of HSG include uterine filling defects and uterine contour abnormalities. These findings usually require further imaging with ultrasonography or MR imaging.\textsuperscript{3}

Postprocedure Considerations

When the fallopian tubes are patent, contrast spills into the peritoneal cavity and is resorbed. Excretion of the contrast medium primarily is accomplished by the kidneys. This elimination usually occurs in 2 hours or less.\textsuperscript{15} Much of the contrast spills out of the vagina when the cannula is removed. The patient might also experience spotting after the examination; therefore, a sanitary napkin should be provided. Spotting usually lasts fewer than 24 hours.\textsuperscript{24}

Antibiotic prophylaxis might be administered in some cases. If a tubal occlusion has been revealed, antibiotics help prevent infection. Patients with cardiac valvular disease and patients at risk for infection might also be prescribed antibiotics.\textsuperscript{21} Patients should be educated about signs of infection to watch for during the 2 to 4 days following the HSG, including development of fever or foul-smelling vaginal discharge.\textsuperscript{24}

Radiation Exposure and Dose

HSG exposes patients to a minimal amount of ionizing radiation. The extent of exposure depends on many
factors, including equipment, fluoroscopy time duration, number of images obtained, and patient size. Total fluoroscopy time for HSG usually is well under 5 minutes. The ovarian dose is less than 6 mGy, with a range of 2.6 mGy for normal findings with shorter exposure times to 6.9 mGy for abnormal findings with longer exposure times.

**Ultrasonography**

Ultrasonography commonly is used to evaluate the causes of female infertility. A standard, first choice procedure in the diagnostic evaluation of infertility is transvaginal ultrasonography. Ovulation disorders, such as those caused by polycystic ovarian syndrome, can be demonstrated with transvaginal ultrasonography. With polycystic ovaries, the many fluid-filled ovarian cysts create a “string of pearls” appearance on the sonogram (see Figure 11). Polycystic ovarian syndrome is diagnosed if 12 or more follicles are visualized and if they measure 2 mm to 9 mm. An ovarian volume of more than 10 mL also results in this diagnosis.

Although 2-D and 3-D ultrasonography can be used to evaluate women for infertility, the reference standard remains 2-D ultrasonography for diagnosis of most malformations of the uterus. Sonohysterography also is gaining popularity for evaluating the uterine cavity and fallopian tubes in women with infertility. Sonohysterography involves using saline to fill the uterine cavity and act as a contrast agent to more easily display differentiations between polyps and uterine fibroids. Uterine synechiae (adhesions), polyps, and fibroids can be evaluated further with sonohysterography (see Figure 12). Fallopian tube inflammation and resultant pathologies, such as pyosalpinx or hydrosalpinx, also can be evaluated (see Figure 13).

The development of 3-D ultrasonography permits visualization of previously unobtainable views of the uterus. The ability to visualize the uterine cavity and the myometrium of the uterus is the most important advantage of 3-D ultrasonography over HSG. Patient discomfort and procedure-related risk with 3-D ultrasonography also is less than with other modalities.

**Magnetic Resonance Imaging**

MR imaging often is used to evaluate female infertility. Soft tissue structures, such as those comprising...
Interventional Procedures for Women

HSG can be therapeutic in some patients because the injection of contrast can sometimes dilate or straighten a narrowed, tortuous, or blocked uterine tube. However, in cases where fallopian tubes are blocked, recanalization might be necessary.

Fallopian Tube Recanalization

A frequent finding on HSG is proximal tubal obstruction. In approximately 30% of women, tubal disease is the cause of subfertility with 10% to 25% of cases due to proximal tube obstruction. The proximal fallopian tube is predisposed to blockage because of its small caliber, thick-muscled wall and reduced proportion of epithelial ciliated cells.

Recanalization of the fallopian tube can benefit patients with a proximal fallopian tube occlusion and poses a low risk for adverse procedural effects. Fallopian tube recanalization is a fluoroscopically guided interventional procedure. Patients require conscious sedation and vital sign monitoring. This procedure begins in the same manner as HSG. Transcervical instillation of contrast is followed by tubal catheterization and guidewire...
Causes of Male Infertility

Male fertility requires normal spermatogenesis, successful epididymal maturation, and storage of sperm. Furthermore, normal sperm transport and accessory gland function are necessary. Several health issues and medical treatments also can cause male infertility.

Sperm Disorders

Forty percent to 60% of infertility cases are caused by male factors. Infertile men might produce sperm that are irregular in shape, do not move properly, or that are of an inadequate number to fertilize an egg. They also could have a reproductive tract blockage inhibiting sperm ejaculation. Processes that affect the production of sperm or their quality potentially are harmful to male fertility. Two examples are oligospermia (low sperm count) andazoospermia, the absence of spermatozoa and spermatogenic cells in semen and postejaculate urine. The odds of fertilization decrease as sperm count decreases. Therefore, semen analysis is one of the first
tests performed during an infertility workup in men and provides valuable information about the quality and quantity of semen and sperm.\textsuperscript{35}

**Varicoceles**

In subfertile men, a varicocele is the most commonly found abnormality.\textsuperscript{36} The pampiniform venous plexus and internal spermatic vein both are dilated and tortuous.\textsuperscript{37} Varicoceles tend to be seen unilaterally.\textsuperscript{38} Approximately 95\% are found on the left side because of the anatomic position of the veins.\textsuperscript{39,40} The left testicular vein drains into the left renal vein, and the right testicular vein drains directly into the inferior vena cava.\textsuperscript{41} The left testicular vein is much longer, and greater flow resistance is created because of the angle at which it enters the renal vein.\textsuperscript{42}

In patients with a varicocele, blood drainage from the testis is impaired, leading to many proposed reasons for male infertility. Impairment can cause an increase in scrotal temperature, an increase in testicular pressure, and reflux of adrenal metabolites.\textsuperscript{43} When the valves within the veins along the spermatic cord fail, dilatation occurs allowing retrograde blood flow and causing a backup of blood. Occlusion of the left spermatic vein is a common treatment of choice for varicoceles.\textsuperscript{44}

The association with varicoceles and sterility is documented extensively and is based on sperm count and mobility. In men with very large varicoceles, sterility is more likely. It also is more likely if the varicocele has extensive contact with the head of the epididymis and is associated with spontaneous reflux.\textsuperscript{45}

Medical imaging plays a vital role in varicocele diagnosis and staging. Although varicoceles are a frequent finding, most patients are asymptomatic. However, the patient might have shrunken testicles or a scrotum that resembles a bag of worms (see Figure 16).\textsuperscript{46} The preferred method for varicocele assessment is color Doppler ultrasonography.\textsuperscript{47}

**Retrograde Ejaculation**

A retrograde ejaculation occurs when semen enters the bladder rather than being ejaculated outside the body.\textsuperscript{48} During a normal male orgasm, the vas deferens transports sperm to the ejaculatory duct where they are mixed with other seminal fluids. As semen passes through the prostatic urethra, the bladder neck muscles tighten. This prevents ejaculate from entering the urinary bladder. If the bladder neck muscle does not tighten properly, retrograde ejaculation occurs. Many factors can cause this, including bladder neck surgery, prostate surgery, certain medications, and nerve damage (see Figure 17).\textsuperscript{49}

**Obstruction**

The most common cause of vassal obstruction is a vasectomy.\textsuperscript{50} During a vasectomy, the vas deferens is severed and sealed. This prevents sperm from entering the ejaculatory duct. A man still can ejaculate, but sperm is not present in the seminal fluid. A vasectomy sometimes can be reversed, and the success rate is 60\% to 75\% if
Venography is an invasive procedure usually performed after the patient’s infertility diagnosis is confirmed through clinical evaluation and ultrasonography. Because of its invasive nature, venography typically is performed in conjunction with testicular vein embolization. MR imaging also has gained importance in assessing male infertility. Diagnostic imaging often pinpoints the best method for impregnating the female partner, along with identifying the possible causes of infertility.

**Diagnostic Imaging for Men**

Male infertility should not be underestimated when a couple is unable to conceive; it can be responsible for 40% to 60% of cases. Fertility tests for men include semen analysis, hormone testing, genetic testing, testicular biopsy, and blood tests. These tests, along with physical examination, evaluate normal sperm and ejaculation processes. Diagnostic imaging such as transrectal and scrotal ultrasonography procedures most commonly are performed.

Venography can demonstrate reflux into the testicular vein and is the preferred method for varicocele diagnosis. Venography is an invasive procedure usually performed after the patient’s infertility diagnosis is confirmed through clinical evaluation and ultrasonography. Because of its invasive nature, venography typically is performed in conjunction with testicular vein embolization. MR imaging also has gained importance in assessing male infertility. Diagnostic imaging often pinpoints the best method for impregnating the female partner, along with identifying the possible causes of infertility.

**Ultrasonography**

Ultrasonography almost always is the initial medical imaging examination in the investigation of male infertility and plays a vital role in diagnosis. Many correctable causes of male infertility can be evaluated with ultrasonography, including disorders that hinder the normal transport of sperm and congenital abnormalities. Testicular morphology, efferent duct patency, prostatic anomalies, and erectile dysfunction also can be assessed using ultrasonography.

In some situations, such as semen volumes of less than 1.5 mL, transrectal ultrasonography (TRUS) is recommended. Other indications for TRUS are abnormal digital rectal examination and ejaculatory disorders, such as anejaculation, hematospermia, and painful ejaculation. TRUS helps physicians evaluate the distal extraductal system, including the seminal vesicles and ejaculatory ducts. Ejaculatory duct obstruction also can be evaluated with TRUS. Ejaculatory duct obstruction can be caused by cysts near the ejaculatory ducts and seminal vesicle enlargement. TRUS can obtain high-resolution imaging of the prostate gland, seminal vesicles, and ductus deferens, and it is an excellent modality to confirm congenital and acquired abnormalities related to obstructive azoospermia.
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Ultrasonography can be used for initial evaluation of the scrotum. It also can be performed to evaluate testicular masses or palpable nodules. Testicular and peritubular abnormalities, such as varicoceles, can be demonstrated on scrotal ultrasonography. Secondary changes caused by obstruction of the distal genital duct also can be seen.

Color Doppler ultrasonography is essential to varicocele diagnosis, as it best demonstrates blood flow or lack thereof. The patient is asked to perform the Valsalva maneuver, or bear down as if having a bowel movement. The prominent veins are then scanned with the transducer to evaluate the increased blood flow (see Figure 18). The veins also are measured while the patient is bearing down.

Magnetic Resonance Imaging
MR imaging is suitable for evaluating the ductus deferens, seminal vesicles, and ejaculatory ducts. MR imaging can help identify and evaluate varicoceles, ejaculatory duct obstruction, undescended testicles, and agenesis of the seminal vesicles. Changes seen initially with TRUS also can be clarified with a pelvic MR scan. Furthermore, pituitary and cranial pathologies manifested by hormonal disturbances have been excluded using MR imaging of the brain.

Varicocele Embolization
Approximately 30% of male infertility cases are due to varicoceles, with the highest occurrence between ages 15 and 35 years. Treatments for varicoceles include varicocelectomy and varicocele embolization. A varicocelectomy is an invasive surgical procedure performed by a urologist. Varicocele embolization is a minimally invasive interventional procedure that can be performed on an outpatient basis.

Transcatheter embolization is a fluoroscopically guided procedure performed by an interventional radiologist. This procedure restricts blood flow by creating an embolus in a vessel. The purpose of varicocele embolization is to close the gonadal veins completely. Veins drain the primary organs of the body and flow in one direction toward the heart, and valves inside the veins assist with this one-way flow. In varicoceles, faulty valves inside the veins cause a reflux of blood similar to how varicose veins form in the legs. The reflux in the gonadal veins results in dilatation and incompetent veins.

During the embolization, patients require conscious sedation and vital sign monitoring. Commonly, the right internal jugular vein is accessed, and then the

Figure 18. A. Color Doppler image demonstrating blood flow on normal respiration. B. Color Doppler image during Valsalva maneuver showing increased blood flow. Images courtesy of Christopher Iyoob, RDMS, and the Hospital of the University of Pennsylvania.
basic understanding of the structure and function of the male and female reproductive systems also is essential for promoting a couple’s reproductive health and fertility. Research has shown that education about fertility self-care is a key factor in preventing unnecessary delays in the diagnosis and treatment of infertility.

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References


1. The hormone-secreting gland that results from a ruptured ovarian follicle is known as the:
   a. paraurethral gland.
   b. pituitary gland.
   c. hypothalamus.
   d. corpus luteum.

2. Spermatogenesis occurs in which of the following structures?
   a. seminal vesicles
   b. seminiferous tubules
   c. epididymis
   d. vas deferens

3. Which of the following promotes growth of interstitial cells in the testes and stimulates secretion of testosterone in men?
   a. gonadotropin-releasing hormone
   b. progesterone
   c. estrogen
   d. luteinizing hormone

4. Ovulation typically occurs during which day of a woman’s 28-day cycle?
   a. 7
   b. 14
   c. 21
   d. 28

5. In which structure does fertilization typically take place?
   a. vagina
   b. ovary
   c. fallopian tube
   d. uterine body

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6. Which of the following are contraindications to hysterosalpingography (HSG)?
   1. pregnancy
   2. active menstrual bleeding
   3. intrauterine fibroid
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

7. HSG typically is performed during which days following the onset of menstruation?
   a. 1 to 5
   b. 7 to 10
   c. 14 to 20
   d. 21 to 28

8. Which of the following might help reduce cramping caused by contrast media injection during HSG?
   a. prednisone
   b. ibuprofen
   c. diphenhydramine
   d. corticosteroid

9. Which of the following is the most common abnormality found in subfertile men?
   a. varicocele
   b. azoospermia
   c. vassal obstruction
   d. retrograde ejaculation

10. Which of the following maneuvers can help demonstrate prominent veins during color Doppler ultrasonography for varicocele evaluation?
    a. Heimlich
    b. Valsalva
    c. Müeller
    d. Adson