



REVOLUTIONIZING WOMEN'S HEALTH BY INTERVENTION RADIOLOGY: THE TRANSFORMATIVE IMPACT OF INTERVENTIONAL RADIOLOGY ON LIFE-SAVING PROCEDURES AND IMPROVE QUALITY OF LIFE

Radio-Diagnosis

Dr. Amit Shrivastava

Assistant Professor, Department Of Radiodiagnosis, MMIMSR, Mullana, Haryana, India

Dr Radhika Kapoor

Junior Resident, Department Of Radiodiagnosis, MMIMSR, Mullana, Haryana, India

Dr. Chahat Aggarwal

Junior Resident, Department Of Radiodiagnosis, MMIMSR, Mullana, Haryana, India

Dr Ajit Yadav

Vice Chairman, Sir Ganga Ram Hospital, Delhi

Dr. Amit Mittal

Professor And Head, Department Of Radiology, Mmimsr, Mullana, Haryana, India

Dr. Gunjan Jindal*

Post Doctoral Associate, Departments Of Radiology And Clinical Neurosciences, Hotchkiss Brain Institute, University Of Calgary And Foothills Medical Centre, Calgary, AB, Canada. Ex Associate Professor, Department of Radiodiagnosis, MMIMSR, Mullana, Haryana, India *Corresponding Author

ABSTRACT

Women's health is essential not only for improving individual well-being but also critical for maintaining family stability, boosting economic productivity and also contributes to overall societal progress in long term. Women have health issues and varying degrees of disability for a greater portion of their lives than males and more vulnerable to sex-specific illnesses. In this article, we highlight the importance of interventional radiology in the treatment of various conditions that specifically affect women like fibroids, adenomyosis, fallopian tube blockage, breast diseases; and conditions related or more common in women due to pregnancy, like placenta previa, varicose veins, postpartum haemorrhage (PPH), deep vein thrombosis (DVT) and we also discuss disease more common in female compare to male like goitre and osteoarthritis. This article provides a comprehensive overview of the indications, procedural details, outcomes, and advantages of interventional radiology in women's health relative to other treatment options.

KEYWORDS

Intervention radiology, angiography, embolization, ablation

INTRODUCTION :

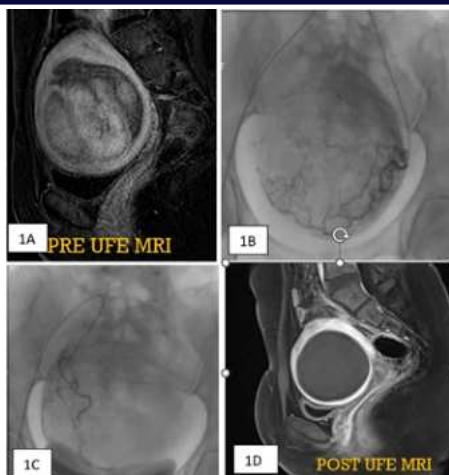
Women play a crucial role in society, serving as the foundation for families and contributing significantly to the development of communities. Women have health issues and varying degrees of disability for a greater portion of their lives than males do. Women typically endure nine or more years of ill health, which limits their potential and makes it more difficult for them to make substantial contribution to their communities, the workforce, and their homes. Women encounter several kinds of health issues throughout their lives, although sex-specific disorders are more frequently experienced by them between the ages of 15 and 50. Addressing the women's health as one of the priorities among health care professional could enhance the quality of life of women and have a good knock-on effect on society, promoting healthy ageing and better health in future generations. Multidisciplinary resources are used to address the issue of women's health, and advancements in treatment and alternatives are rising substantially in recent times. In view of substantial new innovation in the field of Intervention radiology with expansion and new therapeutic applications, Intervention radiology procedures are playing very crucial role in improving the women's health with less pain during and after the procedure, less risk, less hospital stay and better cosmetic results. In this article we are discussing the significance of Intervention radiology in few pathologies exclusively affecting the women like Uterine artery embolization for Fibroid, adenomyosis and PPH, embolization for the pelvic congestion syndrome, breast intervention, and disease related or more prevalent in the women due to pregnancy etc like placenta previa, varicose veins or post-partum deep vein thrombosis and conditions where incidence is more in women compare to men to like knee osteoarthritis needs genicular artery embolization to improve the quality of life. We are going to discuss few of these disease indications, procedure details and review of literature.

1. Uterine Artery Embolization (UAE) For Fibroid, Adenomyosis And Post Partum Haemorrhage PPH:

UAE is well accepted and less intrusive substitute for current surgical for the PPH and fibroid and recent evidence mentioned its role in the adenomyosis also. Fibroids are the most common tumours of the female reproductive system, affecting over 40% of premenopausal

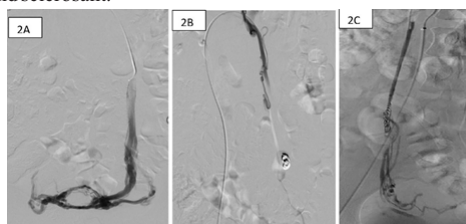
women, with up to 30% experiencing symptoms. (1) Infertility, preterm labour, and miscarriage are associated with fibroids; symptoms include bulk-related difficulties (pelvic pressure, back discomfort, urinary problems), as well as menstrual irregularities (menorrhagia, polymenorrhagia). In UAE femoral or radial artery was accessed and with the help of parent catheter and microcatheter both uterine arteries were superselectively cannulated and embolized with embolic agents like PVA articles. After UAE, average fibroid volume reductions of 50-70%, and sometimes up to 90%, result in significant alleviation of subjective bulk symptoms, an 80-90% satisfaction rate, and the cessation of fibroid-related abnormal uterine bleeding in more than 90% of treated females. (2) Comparison to surgery, UAE patients experience less perioperative issues, shorter hospital stays, and fewer re-admissions. (3)

In the cases of adenomyosis after Uterine artery embolization results in a reduction in uterine volume ranging from 27% to 51% and approximately a 24% decrease in junctional zone thickness, with short-term symptom relief observed in 83.3% to 92.9% of patients depending on the procedure performed for only adenomyosis or adenomyosis with fibroids. (4) Postpartum haemorrhage (PPH) affects approximately 14 million women annually and remains a leading cause of maternal morbidity and mortality worldwide, responsible for about 25% of maternal deaths globally. (5) The aetiologies of primary postpartum haemorrhage (PPH), which manifests within the first 24 hours following delivery, encompass uterine atony, lacerations of the birth canal or perineum, and intrapelvic arterial injuries, whereas secondary PPH, occurring between 24 hours and 12 weeks postpartum, can be attributed to retained products of conception, uterine subinvolution, abnormal placentation with invasive characteristics, uterine arteriovenous fistulas (AVFs), pseudoaneurysms of the uterine artery, and trauma to uterine vessels. (6, 7) According to a meta-analysis, uterine artery embolization demonstrates a high clinical success rate of 89% in treating postpartum haemorrhage while effectively preserving the uterus. (8) (Figure 1A and 1D) shows pre and post procedure MRI images and (Figure 1B and 1C) shows Digital subtraction images of uterine artery embolization.



2. Pelvic Venous Congestion Syndrome (PVCS):

In women of reproductive age, pelvic pain is a common and incapacitating ailment that may be the cause of around 40% of outpatient gynecologic visits.(9) One of the cause of chronic pelvic pain in the female is Pelvic venous congestion syndrome which is a complex and underdiagnosed entity. PVCS was initially identified by Louis Alfred Richet in 1857 and caused by incompetent gonadal vein valves predominantly affecting the premenopausal and multiparous women and is characterized by chronic dull pelvic discomfort, severe pain pressure, and heaviness that lasts longer than 6 months and symptoms are worse with long standing , menstruation and end of the day.(10) Postcoital ache, dyspareunia, dysmenorrhea , , urgency, and varicosities are sign associated with PCS. Ultrasonography (USG) is first line investigation for the pelvic pain and during examination; dilated arcuate vein in the myometrium that communicates with pelvic varicosities, a sluggish blood flow rate (≤ 3 cm/sec), and a tortuous parauterine vein measuring more than 4 mm are concerning for the PCS.(11) Computed tomography (CT) and Magnetic resonance imaging (MRI) with venography confirm the diagnosis, rule out the other causes of venous compression like may thurner's and helping to plan the procedure. A Computed tomography (CT) scan having dilated gonadal vein diameter greater than 8 mm and four ipsilateral convoluted and dilated parauterine veins (at least one >4 mm) is suggestive with PCS. Conventional venography is gold standard but performed with the intention of embolization. Catheter-directed therapy is first line treatment of the PCS which was first reported by Edward et al in 1993.(12) This procedure is performed in an outpatient setting with the patient under moderate sedation. Via internal jugular vein or the femoral vein venography is performed. Selective venography of the left ovarian vein and right ovarian vein followed by embolization with gel foam, sclerosant, glue, Coils, plug in combination. The entire ovarian vein should be treated to lower the risk of recurrence, with the absence of reflux into the veins being the ultimate goal and end point of the treatment. Internal iliac venogram was also performed in the selected set of patients and if reflux is identified, the varicosities can be selectively cannulated and embolized. DeGregorio et al. find significant reduction in visual analog scale pain scores of 85.8% to 93.8% in their study and these results are also supported by systematic review by Daniel et al.(13, 14) No significant change in the menstruation, hormonal levels and fertility after the embolization with significant symptomatic relief making IR as promising option in the patient of PCS. Digital subtraction images (Figure 2A-2C) show ovarian vein venogram and embolization with coils and sclerosant.



3. Fallopian Tube Recanalization (FTR):

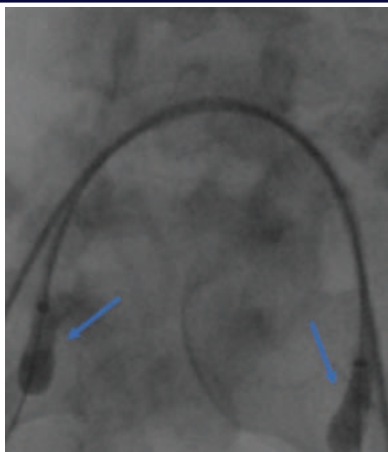
Infertility is a serious issue on a global scale and effect personal and social life. It is estimated that about 186 million people are infertile globally. Tubal infertility has been found to be associated with between

11 and 67% of infertility diagnosis. Of all potential causes of infertility, fallopian tubal diseases accounts for 25% to 35% and Proximal fallopian tube occlusion is responsible for 10% to 25% of these instances. (15, 16) Debris or plugs are the primary cause of proximal blocks in the majority of instances, whereas prior infections are the cause of distal blocks.(17) Hysterosalpingography (HSG) is sometimes applied for therapeutic purposes in addition to determining the block level.; the pregnancy rate following HSG, according to Sulak et al., is 13-55%.(18) The presumed reason for this is that pressure imposed in the uterine cavity during HSG is transmitted into the fallopian tubes, dislodging the amorphous plug from the proximal tube. The technique is performed using a dedicated HSG set, and in case of the block, selective cannulation of the ostium of the block tube with any angle catheter, such as the Kumph catheter, and contrast injection demonstrates filing of the tube and spillage of the contrast. In the situation of a persistent proximal blockage, advance the 0.035 or 0.018 hydrophilic wire to navigate the occlusion and install the microcatheter or parent catheter over it. A follow-up contrast injection is administered to ensure patency and to repeat the maneuver if it fails. Proximal blocks have better results than distal blocks assuming the underlying reason is a past pelvic infection or endometriosis in the case of later. This procedure is performed in the follicular phase of menstrual cycle under fluoroscopy guidance.(19) FTR is natural method of the conception with technical success up to 100% of cases with high pregnancy rate (41%) and full-term successful delivery (84%) over other methods like in vitro fertilization and intracytoplasmic sperm injection.(16, 20) With regard to natural conception, low invasiveness, high technical and clinical success, FTR should be taken into consideration and recommended as one of the options in the scenario of proximal tube obstruction. Fluoroscopy image (Figure 3) shows spillage of the contrast from the both fallopian tube suggest the patency.



4. Balloon Occlusion For Placenta Previa And PPH:

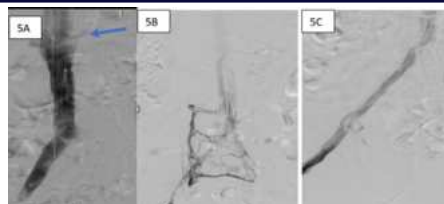
Placenta accrete (PA) and its variants are erroneous placentation illnesses that result in improper postpartum uterine-placental separation. This entity has been attributed to an increase in maternal morbidity and death from potentially fatal uterine haemorrhage because of the highly vascular anatomy of the gravid uterus and placenta, as well as greater adherence of chorionic villi to the myometrium. Placenta accreta is associated with a prior caesarean and the incidence of placenta accreta reach 1 in 275 due to the rising number of caesarean sections. (21) The median bleeding volume ranges from 2000 mL to 7800 mL, and in the past, hysterectomy was frequently performed for controlling intractable postpartum haemorrhages. But in the era of intervention radiology uterus can be preserved by placing the balloon before the delivery. Both femoral arteries were accessed under ultrasound and 7F sheath placed and occlusion balloon were placed using fluoroscopic guidance within the internal iliac artery. Depending on the case basis and institutional protocol more selective occlusion of the anterior division of the internal iliac artery, or less selective occlusion in vessels such as the common iliac artery or even the infrarenal abdominal aorta can be performed. After achieving satisfactory postoperative haemostasis, deflate the balloons and remove the catheters. This procedure reduces the intra-operative blood loss, blood transfusions, longer hospital stays, avoidance of caesarean hysterectomy, and mortality.(22, 23) Fluoroscopy image (Fig 4) showing occlusion balloon in the bilateral iliac artery using bilateral femoral artery access.



5. Venous Thromboembolism (VTE)- Inferior Vena Cava (IVC) Filter Placement And Thrombolysis/ Thrombectomy For Deep Vein Thrombosis (dvt) And Pulmonary Embolism:

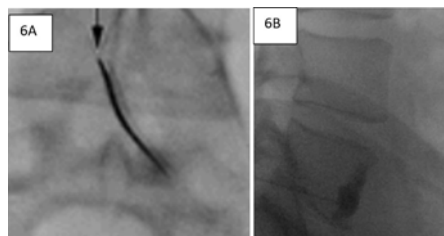
VTE is multifaceted condition associated with a significant mortality rate, morbidity, and financial burden. The incidence of VTE is higher in women than in men in younger age groups due to female reproductive risk factors. Pregnant women have a five-fold increased risk of developing DVT. (24) Diagnosis and management of VTE is complex in terms of mother and fetal well-being. The diagnosis of the DVT is routinely established by the USG and D-dimer test; however, CT venography, MR venography and intravascular USG beneficial during the planning and treatment. Pulmonary thromboembolism is diagnosed with CT pulmonary angiography and ventilation/perfusion lung scan. For DVT anticoagulation is the first line of treatment and in certain instances Catheter directed thrombolysis and mechanic pharmacochemical thrombectomy are indicated in which tissue plasminogen activator (tPA) is commonly used as thrombolytic agent. Using an image-guided multi-side-hole catheter, a fibrinolytic drug is injected into the venous thrombus during catheter-directed thrombolysis (CDT). Large-bore mechanical aspiration tools are used in percutaneous mechanical thrombectomy (PMT) to eliminate DVT. Combining PMT and CDT leads to thrombus breakdown in pharmacochemical catheter-directed thrombolysis (PCDT). PCDT is the most effective, it requires a lower dose of the thrombolytic medication and saves a substantial amount of treatment time and hospital expenditures. As per ATTRACT trial pharmacochemical catheter-directed thrombolysis are better compared to anticoagulation alone in terms of improvement in quality of life and reduce the severity of post-thrombotic syndrome.(25) An IVC filter is inserted to avert pulmonary embolism (PE) or its progression. In accordance with SIR guidelines, the majority of IVC filters were inserted during pregnancy in cases where there were obvious evidence of failure of medical therapy and complications due to anticoagulation.

Commonly using Femoral or jugular approach, after venogram in Fluro guidance IVC filter was placed above the renal veins. New generation IVC filters are placed temporary and removed as soon as not required. Interventional radiology treatment for pulmonary embolism is increasingly being used as a viable substitute for systemic thrombolysis and surgery in cases of substantial pulmonary embolism, hemodynamic instability, or right heart failure. Interventional radiology treatments encompass percutaneous endovascular catheter-directed therapies, including selective thrombolysis and thrombus aspiration in cases of deep vein thrombosis (DVT). A catheter with several holes can be used in catheter directed thrombolysis (CDT) to administer a fibrinolytic drug, such as tissue plasminogen activator. The benefit of locally administering a high concentration of fibrinolytic drug at a much lower dose than the systemic dose is enhanced by high local blood concentration, which also reduces problems. (26) Mechanical thrombectomy or endovascular aspiration are very helpful techniques to quickly declot an involved pulmonary artery thrombus, lower pulmonary pressure, and minimize the chance of RV failure. (27) Digital subtraction angiography images (Figure 5A, 5B and 5C) showing optimal position of the IVC filter; pre and post procedure images of the mechanical chemical thrombectomy and angioplasty.



6. Nerve Block For Pain Associated To Gynaecological Causes:

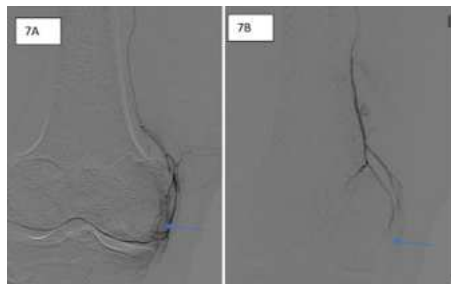
Nerve blocks are a significant technique in the management of chronic pelvic pain, offering targeted relief by disrupting pain signal transmission. The key advantages of nerve blocks are significant pain reduction, minimal invasiveness, and the capacity to locate the cause of discomfort and utilize that information to guide and inform subsequent therapeutic techniques. We are mentioning few nerve blocks and discussing the technique of the superior hypogastric nerve block commonly employed for alleviating pelvic pain in women, which can arise from conditions such as malignancy, endometriosis, fibroid embolization, and disorders of the pelvic floor and perineal region. In superior hypogastric block the fifth Lumbar vertebral body is positioned in a true anteroposterior view under fluoroscopy. Chiba needle (22G) is advanced by using a straight anterior-to-posterior approach into the anterior bony surface of the spine, approximately one-half to one whole vertebral body below the aortic bifurcation as indicated by the angiographic catheter position. Once the needle touched the bone, 3 mL of 1% lidocaine with epinephrine is injected while the operator watched for an increase in heart rate, which would indicate entrance of epinephrine into the bloodstream, a contraindication to injecting the long-acting block agent. If no increase in heart rate is seen, 3 mL of 50:50 diluted contrast is injected to further confirm that the needle is not intravascular and to demonstrate contrast agent distribution to both sides of the vertebral body. Initially 3 mL of 0.5% ropivacaine is then injected, if there is no change in heart rate or neurologic status, the remaining 17 mL of the total of 20 mL injected. In the place of bupivacaine; ropivacaine, steroid, phenol, ethanol can be used and superior hypogastric plexus block provides long-lasting relief in many patients. (28) Pudendal nerve block and Ganglion impar block also used for pelvic pain that can be administered with the use of USG, CT, or fluoroscopy and have excellent results in pain management. (29) Fluoroscopic Image (6A and 6B) shows placement of Chiba needle and injection of diluted contrast for extravascular location.



7. Genicular Artery Embolization:

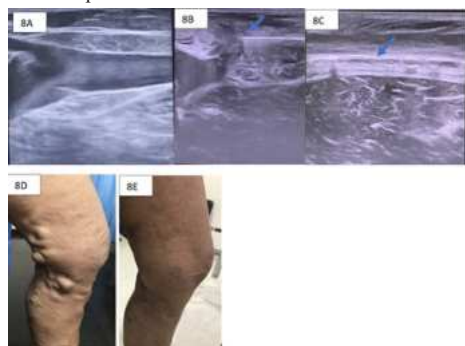
The World Health Organization estimates that musculoskeletal disorders cause the deaths or disabilities of about 65% of women and 30% of men.(30) Osteoarthritis (OA) of the knee is a growing global healthcare concern primarily affects older adults and women going through menopause and an estimated 300 million people worldwide suffer from osteoarthritis. (31) Compared to men, women with OA experienced more severe pain, inflammation, and physical challenges. (32) Genicular artery embolization (GAE) is an innovative technique used when medicinal therapies are ineffective and surgery is contraindicated, or the patient has mild to moderate osteoarthritis. The inflammatory response results in neoangiogenesis and synovial hyperemia, which are the causes of cartilage degradation, pain and dysfunction. The goal of GAE is to selectively embolize the genicular artery corresponding to the pain site to reduce abnormal neovascularity and impede the process that causes pain to subside. under conscious sedation angiography was performed with 4French (F) catheter to determine which genicular branches should supply the areas of hyperemia. Using a microcatheter, the abnormal branch is selectively cannulated and embolized with imipenem/cilastatin, embozene, resorbable microspheres, and polyvinyl alcohol until the neovascularity is adequately pruned.(33) Following GAE, scores on pain scoring tools such as the Visual Analogue Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) shows significant reduction with less need for pain

medications such as opioids, nonsteroidal anti-inflammatory medicines, and intra-articular hyaluronic acid injections.(34, 35) GAE has been established as minimally invasive safe and promising treatment modality for patients suffering from knee pain secondary to OA. Digital subtraction angiography images (Figure 7A and 7B) showing selective angiogram of the descending genicular artery before and after the embolization.



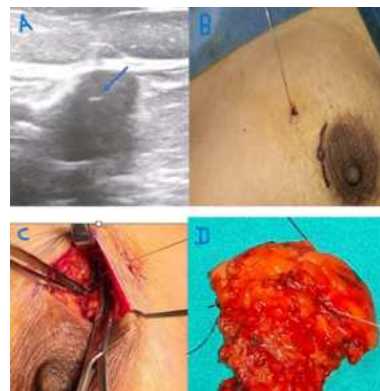
8. Varicose Veins:

Varicose veins are swollen and often painful veins greater than or equal to three millimeters involving the saphenous veins, saphenous tributaries, or non-saphenous superficial leg veins. This is a societal issue especially for women in addition to being medical and cosmetic problems leading to financial burden to the family in neglected cases. Women have a higher prevalence of varicose veins (55%) than males (45%), with 41% of women over 50 having them. If one parent is affected, daughters have a 60% chance of varicose veins. moderately overweight (BMI 25-29.9) have a 50% increased risk of developing varicose veins and BMI greater than 30 are three times as likely to develop varicose veins. Multiple research studies have shown that pregnancy substantially raises the incidence of VVs due to a variety of physiological changes that occur during pregnancy, including an increase in blood volume, weight gain, vasodilatation, fetal development, and abdominal pressure. Initially, the patient was asymptomatic, but pain, aching, discomfort, swelling, heaviness, and itching developed, followed by eczema or pigmentation and in ignored instances presented with superficial vein thrombosis and venous ulcer affecting the quality of the life.(36, 37) Compression stockings and lifestyle adjustments such as weight loss, avoiding prolonged standing and sitting can help treat varicose veins early on. Multiple intervention radiology methods available to treat varicose veins like sclerotherapy that is access of varicosities with small needle 26G and instillation of Foam consist of sclerotherapy agent like polidachanol and air. In case of incompetent junction and large incompetent perforation ablation is recommended with sclerotherapy. Thermal ablation technique includes Laser, Radiofrequency ablation, microwave, Glue and non-thermal catheter-based techniques includes mechanochemical ablation devices (MOCA) and cyanoacrylate glue.(38) In thermal ablation techniques greater saphenous vein or short saphenous vein are accessed and 6french/7 French sheath was placed. To optimize ablation result and reduce the risk of burns and discomfort during treatment, the ablation fibre's tip was positioned 2 cm proximal to the junction and good amount of tumescent instillation. In glue no need for tumescent anesthesia and compression was applied during the procedure after injecting the glue. In line with published studies, ablation offers advantages over surgery, including a decreased risk of hematoma, ecchymosis, and discomfort; a better effect on quality of life; and a quicker recovery period with a low rate of recanalization. (39) USG images (Figure 8A-8C) showing before , during and after procedure image of Greater saphenous vein (GSV) and actual photograph (Figure 8D-8E) of the patient's varicosities before and after the ablation procedure.



9. Breast Intervention:

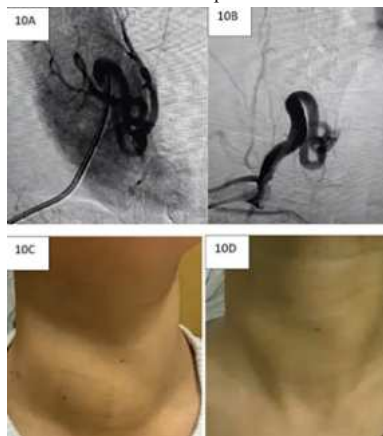
Breast cancer is the most commonly diagnosed cancer, surpassing lung cancer, and the fifth highest cause of cancer death among women globally. (40) Benign breast lesions are also frequent in clinical practice. FNAC and biopsy procedures were performed under imaging guidance like Ultrasound, fluoroscopy or MRI guidance to establish the diagnosis ensure that the pathologic diagnosis explains the imaging finding. Vacuum assisted biopsy is advantageous over routine biopsy because it allows for the rapid removal of a sizable volume of tissue while reducing negative samples and bleeding. It is achieved by using large bore biopsy equipment (12 to 7 gauge) in conjunction with a vacuum generating device. This is not only utilized for diagnostic sampling, but also for the therapeutic management of benign lesions like fibroadenoma.(41) For benign lesion cryoablation, Microwave Radiofrequency ablation, irreversible electroporation and High intensity focussed ultrasound are used by intervention radiologist for treating benign lesion of breast. (42) Preoperative wire localization is safe, and cost-effective method for precisely locating nonpalpable breast lesion commonly performed under ultrasound guidance. This is a 3–15 cm wire, usually with a terminal hook or pigtail, is inserted through the skin by the intervention radiologist and variable part of the wire comes out of the skin and the surgeon removes it together with a variable amount of breast tissue.(43) USG image (Figure 9A) shows wire placement using USG guidance; Patient actual images (Figure 9B-9C) show preoperative, intraoperative and postoperative wire position inside the lesion.



10. Thyroid Intervention:

Thyroid gland nodules are a common occurrence and in the era of USG incidental findings of nodules are significantly increased with a prevalence of 20–76%. Thyroid nodules are around four times more common in women than men and a prevalence of 5.3% in women.(44) These nodules can impact women's overall health by increasing in size and leading to multinodular goitre. Pregnancy is associated with an increase in the size of preexisting thyroid nodules as well as the formation of new nodules. Symptoms associated with nodules are dyspnoea, dysphagia, hoarseness, hyperthyroidism or cosmetic problems. (45) Ultrasound guided fine needle aspiration cytology/ biopsy is considered the gold standard to establish the diagnosis and type of thyroid nodules due to less risk, reliability, and outstanding patient resilience. This is recommended when a nodule measures more than 5 to 10 mm and has questionable US characteristics and in the presence of suspicious lymph nodes, extrathyroidal growth, and a personal or family history of thyroid cancer.(46) Both minimally invasive procedures and surgery are options for thyroid nodules; however, minimally invasive procedures have advantages over surgery, such as preserving more of the thyroid to maintain thyroid function overall, being performed under local anaesthesia, having fewer complications, requiring less time in the hospital, and providing cosmetic benefits that improve quality of life. Current numerous studies expanded its indication for the treatment of primary and recurring well-differentiated thyroid cancer.(47) Preprocedural diagnosis of the nodule to be benign establish by USG features with one or two consecutive FNAC/ biopsy. Multiple ablative techniques are available like percutaneous ethanol injection, radiofrequency ablation (RFA), microwave ablation (MWA) and high intensity focussed ultrasound (HIFU). Most frequently used ablative techniques are RFA and MWA. Procedure is performed in the Local anaesthesia with mild sedation under USG guidance using moving shot technique. Volume reduction for benign nonfunctioning thyroid nodules was apparent within the first month and increased to more than 80% at the one-year mark. A meta-analysis and supplementary level I data suggest

that Thyroid stimulation hormones normalization with symptom reduction and cosmetic benefits for the majority of patients (71.2%) after one year.(48) Thyroid artery embolization is a new treatment option for the nodular goitre especially toxic goitre. In this procedure super selective cannulation of the bilateral superior and inferior thyroid artery and embolized with PVA particles. Evidence indicates that TAE reduces the volumes of goitre and nodules which may significantly improve patients' hormonal condition and quality of life.(49) Digital subtraction angiography images shows selective angiogram of right inferior thyroid artery before (Fig 10A) and after (Fig 10B) the embolization with PVA particle.



CONCLUSION:

Interventional radiology plays a crucial role in the treatment of various women's health conditions, providing minimally invasive alternatives to traditional surgical approaches. Its importance lies in qualities like minimally invasive techniques, targeted treatment, less pain and pain management during the procedure, reduced hospital stay, a quicker return to normal activities, diagnostic and therapeutic integration, fewer cosmetic concerns, less risk and excellent clinical outcome. We hope that our article spreads awareness about transformative role of Interventional radiology in the management of various women's health conditions, utilizing precision-driven, minimally invasive methods to address a broad spectrum of women's issues effectively and addressing the women's health gap so we can improve the health of future generations as well as provide a boost to healthy society.

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