Diagnostic imaging of breasts and reproductive system

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The objectives of the diagnostic imaging of breasts

1. Detecting the preclinical stage of breast cancer in asymptomatic women
2. Investigation of breast pathology in women with certain clinical symptoms:
   - Breast pain, dependent or independent of cycle (mastalgia, breast tenderness)
   - Palpable nodule, breast tumor
   - Nipple discharge
3. Follow-up of previously identified benign breast diseases
4. Breast assessment before and during hormone therapy
Diagnostic methods

1. Clinical examination, including:
   - interview
   - physical examination (breast palpation)
2. Mammography
3. Ultrasound (B-mode, Color Doppler, Power Doppler, 3D, elastography)
4. Biopsy and cytological investigation
5. Histopathological investigation
6. MRI mammography
7. Isotopic examinations
Diagnostic methods

Remember:
Mammography and ultrasound-assisted breast biopsy are complementary studies, supplementing their diagnostic capabilities.

The use of combined or separate mammography and ultrasound-assisted biopsy is dependent on:

- Age of woman
- Breast tissue composition
- Perceptible changes in palpation of the breast and armpit
- Data from the interview
Which imaging method should you use?

- Below 35 years of age - An ultrasound!
- 35 - 50 years - mammography or ultrasound
- Over 50 years – mammography, possibly complementary ultrasound

Exercise:
Think about and try to explain why exactly such scheme.
Clinical examination

- It is a very important part of the diagnostic process, helping in the interpretation of imaging studies.

- **10-15%** of breast cancers *are not* visible in mammography, but can be recognized by a clinical examination.
Clinical examination

- Examine breasts in various body positions, with both visual assessment and palpation (note the symmetry of breasts, the skin, nipples, breast density, and the presence of focal lesions)

- Remember to pay a special attention to assessment of upper outer quadrant of breast (UOQ) - 50% of cancers arise in this location

- Palpation of armpits and supraclavicular fossae (detection of enlarged lymph nodes)

- Optimal time for testing: 7-10th day of cycle

It should be noted that statistically, out of 10 breast tumors detected by palpation, only one is malicious.
In Poland, only 25% of women performed a clinical breast examination and mammography screening frequency does not exceed 10% per annum.
Other breast imaging possibilities

- **Digital mammography** – provides a digital image processing capability, image transfer, archiving, reduction of radiation dose, semi-automatic analysis of microcalcifications, etc.
- **Mammoscintigraphy** - worse resolution than mammography
- **Radionuclide imaging** of the lymphatic system – imaging of so-called sentinel node
- **PET** (positon emission tomography) - assessment of the primary tumor and metastatic foci
Quadrants of the breast

Source: http://training.seer.cancer.gov/breast/anatomy/quadrants.html
Breast self-examination

Radial - from the nipple to the periphery

Spiral - from the nipple to the periphery;

From top to bottom and from bottom to top

Careful examination of both armpits

Nipple discharge test
Breast self-examination: what should alarm

- Changes in the shape, size or position of the breast
- Different behavior of breasts while lifting arms
- Wrinkles, retraction of the skin of breast, change of the skin color and characteristic, so-called „orange peel skin” (Peau d’orange) on the surface of the breast
- Retraction/protrusion, reddening or ulceration of nipple
- Nipple discharge (serous or sanguineous)
- Nodule or limited induration of breast, differing in consistency from the rest of breast
- Enlarged lymph nodes under the arm
Mammography
Mammography

- Mammography is a low-dose X-ray exam of the breasts.
- It uses low-energy X-rays (usually around 30 kVp) to examine the human breast and is used as a diagnostic and a screening tool.
- The goal of mammography is the early detection of breast cancer, typically through detection of characteristic masses and/or microcalcifications.
- The results are recorded on X-ray film or directly into a computer system (digital mammography).
Indications for mammography

- Changes detected during breast palpation
- Enlarged axillary lymph nodes
- Breast pain regardless of the cycle (mastodynia)
- Monitoring of fibrocystic dysplasia of the breast
- Following a surgical treatment of breast cancer – evaluation of the contralateral breast once a year
- Family history of breast cancer
- Patients during hormone replacement therapy (MMG once a year, ultrasound every 6 months)
Types (projections) of mammograms

- craniocaudal projection (C-C)
- oblique projection
- lateral projection
- targeted mammograms
- enlarged mammograms
- other specialized projections (e.g., cleavage = “valley” view, axillary = “Cleopatra” view)
oblique projection

craniocaudal projection
Anatomy of the breast
Types of the breast tissue composition

- Glandular and stromal tissue on Mammography
- Hyperechoic structures on ultrasound

Adolescent breast
Mature, pre-menopausal breast

- Hypoechoic fat "islands" scattered among hyperechoic glandular tissue
Types of the breast tissue composition

Postmenopausal, involutional breast

On ultrasound: mostly hypoechoic adipose tissue with an amount of hyperechoic stromal elements
Types of the breast tissue composition

Breasts of pregnant and lactating women

- small glandular parenchymal weaving, a significant increase in the amount of glandular tissue

**Remember:**

In pregnant women, there shall be no mammography, ultrasound only!
Causes of errors in the evaluation of mammography

- Composition of the breast - "dense breast"
- Lesion in area which is difficult to visualize (eg. tail of Spence)
- Technical reasons - faulty technique, artifacts on films or cassettes
- Errors of interpretation - up to 30%
  - Does not notice changes
  - Incorrect assessment of pathology found

Note that existing breast cancer may be not detected in 20-25% mammographic examinations (false-negative results)
Indications for ultrasound

- Palpable change
- Radiographically dense breast
- Changes of uncertain nature in mammography:
  - focal lesion?
  - cyst or solid lesion?
  - solid lesion: benign or malignant?
- Control of benign lesions in breasts
- Inflammation
- Pregnancy and lactation
- Breast trauma
Indications for ultrasound (continued)

- Postoperative control (hematomas, fluid reservoirs)
- Mastectomy follow-up (assessment of scarring and chest wall)
- Monitoring the effects of pharmacotherapy
- Ultrasound-assisted biopsy
- Preoperative localization of changes
- Assessment of axillary lymph nodes
Assessment of milk ducts

- Diameter: ≤ 2 mm, directly behind the nipple
  ≤ 4.5 mm
- Borders - smooth, irregular
- Low echogenicity
- Search for intraductal focal lesions
The efficacy of ultrasound in the differentiation:

- Solid or cystic lesion: ~ 100%
- Solid benign or solid malignant lesion: 85%
- Cystic benign or cystic malignant lesion: 92%

Notice!
10% of nodules with features of benign lesions may be malignant.
Ultrasonography with Color Doppler and Power Doppler

- Allows the assessment of tumor-induced neoangiogenesis
- In many tumors a number of vessels are visible, typically irregularly arranged, reaching to the periphery of the lesion, with arteriovenous fistulae and low resistance flow
- Lack of blood flow does not exclude malignancy (!)
- US image should be considered in conjunction with other methods
- The use of contrast agents substantially increases the sensitivity and specificity (80 -95%)
- useful for monitoring the treatment of inoperable cancer and for differential diagnosis of scarring and recurrence after surgery
3D ultrasound imaging

- three-dimensional data collection and presentation on a two-dimensional image based on the number of cross-sections obtained by a special volumetric probe and their reconstruction in three mutually perpendicular planes
- for tumors' imaging, a so-called "volumetric reconstruction" is used
Ultrasound-guided interventions

A biopsy should always be performed under the supervision of a stereotactic mammogram or ultrasound.

Biopsy should always be performed by cytologist or pathologist in collaboration with the radiologist or ultrasononographist.

Indications for ultrasound-guided biopsy:

- A focal lesion, palpable or imperceptible (if visible by ultrasound), which appearance does not allow to exclude cancer
- Palpable or visualized by ultrasound abnormal axillary lymph nodes
- Draining the fluid-filled spaces in the breast (like cyst, abscess, hematoma)
Ultrasound-guided interventions

1. FNAB (fine needle aspiration biopsy) - cell suspension from smear
   Indications:
   - Fluid lesions which do not meet the criteria for a simple cyst
   - Lesions which are suspected of malignant process
   - Ambiguous lesions
   - Solid masses, which are probably benign

2. Core biopsy

3. Mammotome (vacuum assisted breast biopsy with image guidance such as mammography, ultrasound and/or MRI)
## Prevention of breast cancer

<table>
<thead>
<tr>
<th>Age</th>
<th>Preventive actions</th>
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<tbody>
<tr>
<td>20 - 35</td>
<td>Self-examination once a month</td>
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<tr>
<td>35 – 39</td>
<td>Breast examination by a doctor once a year</td>
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<tr>
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<td>1 mammogram within 5 years</td>
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<tr>
<td></td>
<td>Ultrasound once a year</td>
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<td>40 – 49</td>
<td>Mammogram every 2 years</td>
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<td>(if necessary, supplemented by ultrasound)</td>
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<tr>
<td>Above 50</td>
<td>Breast examination by a physician 1-2 times a year</td>
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<tr>
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<td>Mammogram once a year (if necessary, supplemented by ultrasound)</td>
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<tr>
<td>Above 60</td>
<td>Mammogram every 1.5-2 years to 75 years of age</td>
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<tr>
<td>Hormone</td>
<td>Mammogram once a year</td>
</tr>
<tr>
<td>Replacement</td>
<td>Ultrasound every six months.</td>
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<tr>
<td>Therapy</td>
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</table>
Galactography

Visualization of milk ducts by injecting a small amount of non-ionic contrast agent into their ostia, and performing mammography in two projections.

Indications:
- Idiopathic, single-nipple, serous/sanguineous or mixed discharge
- Multiductal sanguineous discharge
- Abnormal cytology secretions
Galactography

The most common causes of serous or sanguineous nipple discharge:
- Intraductal papilloma or papillomatosis - 56%
- Fibro-cystic dysplasia - 22%
- Duct ectasiae - 12%
- Cancer (bloody discharge) - 10%

Galactography detects:
- Obstruction of contrast enhancement in milk ducts
- Ducts ectasiae
- Small cystic changes
- Locates intraductal hyperplasia

It does not differentiate benign from malignant growth
Nipple discharge

Causes of milky discharge:
- pregnancy, lactation
- physiological galactorrhea in adolescence
- medications (contraceptives, antidepressants) and narcotics
- thyroid disease
- pituitary micro- or macroadenoma
Galactography
MRI Mammography

Indications:
- Patients with ambiguous diagnosis (e.g., inconsistency in clinical examination and mammography / ultrasound, negative FNAB when cancer is strongly suspected), especially in cases of mammographically dense breasts.
- The presence of enlarged, suspicious axillary lymph nodes in the absence of changes in the physical examination, mammography and ultrasound.
- State after conserving treatment of breast cancer; concerns or difficulties in assessing the lodge in classical imaging methods.
- Eligibility for surgery (excluding multifocal changes, especially in the planning of conservative treatment; staging - qualification for induction chemotherapy).
- Diagnosing known BRCA1/BRCA2 mutation carriers.
- Evaluation of breasts after implantation of breast implants (tightness of implant, condition of tissues behind the implant).
- Evaluation of breasts after implantation of silicone fluid.
MRI Mammography

Contraindications:
- Typical, just like regular MRI
- Posture defects with a significant degree of deformation (when patient cannot lay in a prone position)
- Extremely large breasts (will not fit in the coil).

The sensitivity of MRI mammography in pre-invasive lesions (in-situ cancer) is much lower than in changes that are already invasive (false-negative results).

The nature of enlarged lymph nodes (inflammatory or metastatic) cannot be reliably assessed by MRI.

MANDATORY is performing MRI between 7 and 14 day of cycle, and at least 3 months after discontinuation of hormone therapy.

Also, it should not be performer earlier than 12 months from surgery and radiotherapy.
Classification of breast tumors

I. Epithelial neoplasms:
   1. Benign
      - Intraductal papilloma
      - Adenoma of the nipple
      - Adenoma
   2. Malignant
      - Preinvasive cancers
        a. Intraductal (DCIS – ductal Larcinoma in situ)
        b. Lobular (LCIS - lobular carcinoma in situ)
      - Invasive cancers
        a. Ductal 80%
        b. Lobular 8-10%
        c. Mucic 1-2%
        d. Medullary 5%
        e. Papillary 1.5-2%
        f. Tubular
        g. Adenoid cystic breast cancer

II. Mixed neoplasms:
   - Fibroadenoma

III. Nonepithelial tumors:
   - Fibroma
   - Lipoma

IV. Benign breast dysplasia

V. Tumor-like growths

VI. Nonclassified changes
Breast cancer

- The most common malignant tumor in women
- The most common cause of death from cancer in women
- 10,000 – 11,000 new cases each year in Poland
- 5-year survival:
  - USA - 75%
  - Poland - 50%
  (...and that’s because in Poland, 70% of patients report when already in T2/T3 stage)
- Early stage cancer detection rate:
  - USA, Sweden, the Netherlands - 80%
  - Poland - 20% (yes, we have to improve...)
Risk factors for breast cancer

- Breast cancer in the family (mother, grandmother and their sister, patient’s sister - before 35 years of age)
- Bilateral breast cancer in mother (the risk reaches 50%)
- Age (50-70 yrs)
- Early first menstruation (before 12 years of age), late menopause (after 55 yrs)
- Childlessness
- Late age at first childbirth (30 yrs)
- Hormone treatment (long-term contraception at young age or HRT raises risk by 6%)
- Hyperestrogenism
- A history of breast cancer in second breast - the risk increases every year by 1%
- BRCA1, BRCA2 and p53 genes carriers (these factors are responsible for 10% of all breast cancers), the risk increases up to 80%
- Lifestyle (high caloric diet, frequent alcohol consumption, low physical activity)
- Geographical location (often western European countries and USA, rarely asians and black people)
Estimating the amount of risk of breast cancer

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Risk Factors</th>
</tr>
</thead>
</table>
| 1-2 times larger            | • City as a place of residence  
• Early first menstruation  
• Late menopause           |
| 2-3 times higher            | • High socioeconomic status  
• First childbirth after age of 30  
• Obesity (>30% above normal weight)  
• Benign changes in the breast  
• Childlessness               |
| 3-4 times higher            | • Two cases of breast cancer in closest relatives  
• Irradiation of the surrounding of breast for reasons other than breast cancer |
| More than five times larger | • Three cases of breast cancers in closest relatives  
• Cancer of the second breast or 2 breast cancers in first degree relatives, developed before age of 50 |
| 20-fold higher              | • Age above 50 years of age (compared to 35-39 years of age)  
• Presence of specific mutations in the BRCA-1  
• Cancer of the second breast |
Clinical symptoms of breast cancer

- breast tumor, typically irregular and with increased cohesiveness,
- retraction of the skin or nipple,
- change in the size or shape of the breast,
- different behavior of the breasts while lifting both arms,
- skin changes around the nipple (Paget carcinoma),
- nipple discharge (especially bloody),
- redness, hardening and thickening of the skin, enlargement of pores, "orange peel" (differential diagnosis: inflammatory cancer and mastitis),
- enlarged lymph nodes in the armpit,
- enlarged veins on skin of the breast,
- ulceration of the skin of the breast,
- swelling of the arm,
- pain (caused by distant metastases),
- breast pain - happens only in 7-10% of cases (more frequently associated with a benign lesions).
Symptoms of breast cancer in mammography

- spicular nodule - 80% of palpable breast cancers
- architectural distortion
- asymmetric tissue
- nodule with the blurry, indistinct boundaries
- smoothly outlined nodule - 5% of cancers
- microcalcifications in nodule - 35-90% of cancers
- cluster of microcalcifications, even when without a visible nodule
Spicular mass in breast

Breast cancers
Well defined nodules in breast
Calcifications in the breast

Macroccalcifications:
- Benign
- Single or uniformly distributed when multiple, symmetrically in both breasts
- In the skin, subcutaneous tissue, scars, fat necrosis, FA, oil cyst, duct ectasy, blood vessels, benign dysplasia)

Microcalcifications:
- Malignant (75% of DCIS are manifested only by microcalcifications) or benign
- Most alarming are:
  - Clusters of microcalcifications
  - Polymorphic microcalcifications
  - Various shaped microcalcifications
  - Branching microcalcifications

Remember! Ultrasound is not a method of detecting microcalcifications!
Examples of macrocrococalcifications (benign)

- "Popcorn" calcification (involuted fibroadenoma)
- Skin calcifications of the areola
- Vascular calcifications
- Oil cysts
Examples of microcrococalcifications

Fine pleomorphic calcifications in a segmental distribution.
High grade DCIS in biopsy.
Sonographic symptoms of a typical breast cancer

- low echogenicity
- circular shape or perpendicular arrangement relative to the surface of the skin
- irregular contours
- heterogeneous echostructure
- dorsal acoustic shadowing
- echogenic halo (desmoplastic reaction)

In a large tumor in addition:
- infiltration of the fascia and the pectoralis major muscle
- neovascularization (Color/Power Doppler mode)
- lymph node involvement
BI-RADS
(Breast Imaging-Reporting and Data System)

- BI-RADS is a system created by the American College of Radiology (ACR) to standardize descriptions of mammographic examinations.
- It’s a quality assurance tool originally designed for use with mammography, later adopted for ultrasound and MRI.
- BI-RADS defines the terminology that should be used in reports from examinations, the structure of the description and categories of the final evaluation with the conclusions defining the further course of action.
**BI-RADS**
(Breast Imaging-Reporting and Data System)

<table>
<thead>
<tr>
<th>Score</th>
<th>Assessment category</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Incomplete</td>
<td>requires additional diagnostic imaging, the risk of malignancy in this stage is uncertain and difficult to assess</td>
</tr>
<tr>
<td>1</td>
<td>Negative</td>
<td>image completely normal, the risk of malignancy 0%, does not require further investigation</td>
</tr>
<tr>
<td>2</td>
<td>Benign finding(s)</td>
<td>presence of changes which are certainly benign, the risk of malignancy 0%, does not require further investigation</td>
</tr>
<tr>
<td>3</td>
<td>Probably benign</td>
<td>risk of malignancy &lt;2%, indicated control examination in 6 months, recommended additional ultrasound examinations</td>
</tr>
</tbody>
</table>
| 4     | Suspicious abnormality | the risk of malignancy from 2% to 95%, necessary to verify the change  
 the group was divided into three subgroups: 
 4a: suspicious change, but a low degree of probability of malignancy 
 4b: suspicious change, an intermediate degree of probability of malignancy 
 4c: suspicious change, with a high probability of malignancy, but without the classic features of malignancy |
| 5     | Highly suggestive of malignancy | risk of malignancy> 95%, verification of lesion is necessary, as well as further treatment |
| 6     | Proven malignancy    | change previously verified as malicious by biopsy |
Irregularly shaped lesion with indistinct boundaries, complex echo pattern and some acoustic shadowing, highly suggestive of malignancy (BI-RADS-US V).
The mass is irregular, ill defined, hypoechoic, more tall than wide and casting heavy post acoustic shadowing. Doppler examination revealed hypervascularity of the lesion with abnormal high resistance flow.
Inflammatory Breast Cancer

- A relatively uncommon but aggressive form of invasive breast carcinoma
- Has characteristic clinical features and unique radiographic appearances
- Mimics mastitis:
  - breast is enlarged, indurated, erythematous, warm, tender and painful
  - the skin is thickened and oedematous, with a "peau d'orange" appearance
  - there may or may not be an underlying palpable mass

The breast is **not** painful in spite of the alarming appearance on examination.

The clinical presentation, mammography and ultrasound should be differentiated from mastitis!

- Mammography: tumor mass and malignant microcalcifications, inflammatory changes such as extensive skin and trabecular thickening / coarsening, and/or diffusely increased breast density
Mammography and ultrasound in the diagnosis of cancer

<table>
<thead>
<tr>
<th></th>
<th>MMG</th>
<th>USG</th>
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<tbody>
<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 35 years old</td>
<td>76%</td>
<td>84%</td>
</tr>
<tr>
<td>36-40</td>
<td>69%</td>
<td>84%</td>
</tr>
<tr>
<td>41-45</td>
<td>71%</td>
<td>85%</td>
</tr>
<tr>
<td>46-50</td>
<td>75%</td>
<td>77%</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 35 years old</td>
<td>92%</td>
<td>85%</td>
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<td>84%</td>
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</tr>
<tr>
<td>Above 50</td>
<td>89%</td>
<td>87%</td>
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Houssami et al.. AJR 2003, 180(4):953
Mammography and ultrasound – the summary

- Mammography is a very good screening method
- The combined sensitivity of ultrasound and MMG reaches 94.6%
- Ultrasound is not suitable for screening!
  (It may not show focal lesions in fatty breasts).
Diagnostics of breast pain

- Cyclic breast tenderness - 65% of women with breast pain, usually bilateral, in the upper-outer quadrant, may radiate to the axilla, is chronic, hormones-dependent (hyperprolactinemia, hyperestrogenism)
- Non-cyclic breast tenderness (mastalgia) - about 10%, focal or diffuse, 40-50 years of age
- Pain in the breast during pregnancy and lactation
- Mammitis
- Traumatic, after surgery - scarring, fibrosis, fat necrosis
- Thrombophlebitis of the thoraco-epigastric vein (Mondor's disease)
- Diffuse inflammatory breast cancer
Fibrocystic breast disease, fibrocystic dysplasia

Associated with hormonal dysfunction
- hyperestrogenism
- progesterone deficiency
- hyperprolactinemia

Ultrasound image
- cysts, ducts ectasiae, diffuse fibrotic changes, ductal epithelial hyperplasia
Breast cysts

- The result of widening of the milk ducts
- Most common in women between 30 and 50 years of age
- The most frequent focal lesion in breasts
- Asymptomatic or painful palpable tumors
- Size: from a few mm to a few cm
- Single or multiple (related to the fibro-cystic dysplasia)
Ultrasound features of a typical, simple breast cyst

- Anechoic
- Round or oval
- Smoothly bounded thin wall
- Posterior reinforcement (75%)
- Sometimes marginal acoustic shadows
Other causes of cystic and complex lesions

- hematoma
- abscess
- bleeding in solid tumor
- partially necrotic tumor
- neoplastic proliferation in cyst
Indications for FNAB of cyst

- large palpable cysts
- soreness
- cyst with some features of malignancy
- solid mass in the lumen of cyst
- increased vascularity in tissues surrounding the cyst
Intraductal lesions

1. Papilloma
2. Cancer
   - solid mass located in axis of duct, which is often widened
   - subareolar or peripheral location
   - single or multiple
3. Ductal epithelial hyperplasia
   - lumpy contours of ducts
   - decreased echogenicity of ducts
Benign tumors

Adenofibroma (most common before age of 30)

Tumor phyllodes (after age of 30-40, rapidly growing large tumor)

Hamartoma - adenofibrolipoma

Lipoma

Papilloma
Metastases to the breast

1. melanoma
2. lung cancer
3. ovarian cancer in women, prostate cancer in men
4. stomach cancer
5. cervical cancer
6. lymphoma

In mammography and ultrasound, metastases are often well demarcated!
Mammitis

1. Acute - during lactation or with no relation to lactation:
   - Diffuse or localized increase in tissue echogenicity
   - Disturbed parenchymal structure
   - Skin thickening
   - Linear reservoirs of fluid in the subcutaneous tissue (lymphatic vessels, interstitial fluid)
   - Widening of the milk ducts (milk stasis)

2. Abscess:
   - Avascular
   - Varied echogenicity
   - Internal echoes, sometimes moving around
   - Sometimes fluid-fluid level
   - Posterior reinforcement

3. Chronic mammitis:
   - Related to secreting breast

Diagnostics: an ultrasound!

Mammography in non-lactating women with mastitis symptoms and anti-inflammatory treatment failure (DD - inflammatory carcinoma).
Evaluation of lymph nodes in ultrasound

Normal lymph node features:
- Oval
- Hyperechoic hilum
- Hypoechoic cortical layer (parenchyma)

Reactive or metastatic nodes:
- Circular shape
- Decreased echogenicity
- Blurred echotexture
- Cortical hypertrophy
- Hypervascularity in Doppler mode

Effectiveness of metastatic nodes detection by the ultrasound:
- Sensitivity - 90%
- Specificity - 92%
Imaging breasts with implants

Types of breast implants:
- Implants filled with silicone gel
- Saline-filled implants
- Dual chamber implants (silicone and saline)

Implants may be placed:
- into the mammary gland
- under the pectoral muscle (favorable)

Imaging options:
1. Mammography using Eklund’s technique (postero-superior displacement of the implants simultaneously to an anterior traction of the breast)
2. Ultrasound
3. MRI mammography

Collapsed right implant shell with silicone extravasation into the fibrous capsule. MRI, Sagittal T2WI image
Imaging of male breast

1. Gynecomastia
2. Breast cancer
3. Posttraumatic changes
4. Ducts ectasiae
5. Intraductal papilloma
6. Metastases - prostate cancer, melanoma, lung cancer

Imaging methods
- it is recommended to perform routine mammography and ultrasonography in the case of breast enlargement in men above 50 years of age
- in younger - an ultrasound and possibly FNAB in unclear cases, if necessary mammography (with the exception of adolescents and young adults)
Imaging of male breast

Gynecomastia

- One or bilateral breast enlargement due to the influence of estrogen or other factors
- 85% cases of male breast enlargement
- May coexist: breast soreness, nipple retraction, serous or milky nipple discharge
- In chronic states breast tissue density may be greater

1. Physiological (the neonatal period, puberty, after 65 years of age)
2. Pathological
   - deficit of androgens
   - testicular tumor 3%
   - adrenal disease
   - cirrhosis of the liver 8%
   - chronic renal failure
   - pituitary adenoma
   - certain medications (10-20%)
3. Idiopathic 25-30%
Imaging of male breast

Breast cancer
- 1% of all breast cancers
- in Klinefelter syndrome cancer occurs as frequently as in women
- usually located behind the nipple
- more frequently than in women represented by a well defined nodule
The Reproductive system
Diagnostic methods

1. Clinical examination, including:
   - interview
   - physical examination (palpation of the abdomen and external genital organs, vaginal examination, colposcopy)

2. Cytological and histopathological examinations

3. Imaging methods:
   - Plain abdominal X-ray
   - Ultrasound
   - Hysterosalpingography (HSG)
   - Computed tomography
   - MRI
Abdominal X-ray

- limited diagnostic value (normal uterus, ovaries and fallopian tubes absorb X-ray just like the surrounding tissue and thus are invisible on radiograms);
- Pathological changes containing calcified elements will be visible (e.g., calcified uterine fibroids, teeth - pathognomonic for teratomas).
- Should not be performed in pregnant woman!
Abdominal X-ray

- limited diagnostic value (normal uterus and fallopian tubes absorb X-ray just like the surrounding tissue and thus are invisible on radiograms);
- Pathological changes containing calcified elements will be visible (e.g., calcified uterine fibroids, teeth - pathognomonic for teratomas);
- Should not be performed in pregnant women!
Hysterosalpingography

- Most common of conventional radiological examinations.
- Principles: injection of the iodinated contrast agent to the uterine cavity through the cannula placed into the cervical canal, image analysis during fluoroscopy and on x-ray images.
- Allows the assessment of the shape and congenital malformations of the uterus, as well as position of fallopian tubes and tubal impermeability (postinflammatory or due to adhesions).

- Absolute contraindications:
  - pregnancy
  - acute inflammation of the reproductive organ
Ultrasound

- Method of choice for screening of soft tissues.
- Widely used to assess of the anatomy and topography, congenital malformations and pathological changes of the reproductive organs in both mature women and young girls.
- Of the currently used imaging methods, it’s the only one without contraindications (limitations only on 1st trimester).
- Primary examination of the scrotum and penis.
Transvaginal ultrasound

- 7.0-7.5 MHz intravaginal probes
- Better image quality and resolution when imaging ovaries and endometrium
Limitations of ultrasound

- gases in the intestines
- obese patients
- insufficient filling of the bladder
- scars and non-healing wounds of the abdominal wall
- limits in the reproducibility of images
- lack of cooperation from patients in serious condition
- dependence on operator’s experience
Computed tomography

- Multiphase CT
- Intravenous +/- oral +/- intrarectal contrast agent administration
- The patient fasting, laxatives or enema a day before examination
- Mainly when ultrasound result is unclear or for cancer staging
The patient fasting, after miction
- T1WI, T2WI and PD-weighted images prior to contrast administration; SE and FSE, FatSat sequences
- Sagittal, frontal and axial projections
- Gadolinium CM
Diseases of the female reproductive system

**Endometriosis** - a condition in which cells from the endometrium appear and flourish outside the uterine cavity, most commonly on the peritoneum (mainly in rectouterine pouch), ovaries, fallopian tubes, scars.

- Extrauterine endometrium cells undergo a cyclic changes during the menstrual cycle phases.
- Pathogenesis is unknown (retrograde blood flow from uterine cavity into peritoneum during menstruation?); predisposing factors are:
  - Family history
  - History of ectopic pregnancy
  - Asian origin
- Diagnostics:
  - Ultrasound – method of choice
  - CT
  - MRI (high sensitivity in the detection of small foci of endometriosis / bleeding)
  - A certain diagnosis possible after laparoscopy and evaluation of excised pathological lesions

Scar endometriosis (after caesarean section)

Endometrioma (chocolate cyst) of the right ovary. MRI, T2-weighted image
Diseases of the female reproductive system

Tumors of the uterus:

1. Uterine fibroid (leiomyoma):
   - the most common benign tumors in females, typically found during the middle and later reproductive years (35-45 years of age)
   - originates from the smooth muscle layer of the uterus
   - most of them are asymptomatic, but as they grow may cause heavy and painful menstruation, painful sexual intercourse, and urinary frequency/urgency
   - Classification (based on localization): intramural, subserosal, submucosal, cervical. May be single or multiple.
   - Diagnostics:
     - Bimanual examination (larger fibroids)
     - Ultrasonography (focal, typically hypo- or isoechoic masses with a heterogeneous texture, which may cause shadowing of the ultrasound beam, especially when calcified).
     - CT
     - MRI – more precise than US and CT, allows differentiation of benign leiomyoma and malignant leiomyosarcoma
Multiple fibroids. MRI, T2-weighted sagittal scan.

Multiple fibroids with calcifications. CT +C, venous phase.

Fibroid on ultrasound.
Diseases of the female reproductive system

Tumors of the uterus:

2. Endometrial cancer:
   - The most common cancer in postmenopausal women
   - Endometrial thickness above 5 mm in ultrasound requires biopsy
   - MRI is very sensitive yet of a limited specificity in assessment of endometrial hyperplasia, but is considered superior to CT for local staging. Contrast enhanced MRI imaging improves accuracy in detecting myometrial invasion.
   - CT indicated only in advanced stages (the search for infiltration of the surrounding tissues and lymph node metastases)
   - Histological types:
     - adenocarcinoma of the endometrium: commonest histological type: ~ 90%
     - papillary serous carcinoma of the endometrium: 5-10%
     - clear cell carcinoma of the endometrium: <5.5%
     - other, rare types
Advanced endometrial carcinoma (contrast-enhanced CT, arterial phase)

Heterogeneous tumor with features of decay, that extends beyond the true pelvis. Left paraaortic nodal metastases at the renal level, right iliac nodal metastases (arrows). Tumour stage FIGO IVb.
Diseases of the female reproductive system

Tumors of the uterus:

3. Carcinoma of the cervix:
   - Considered the third most common gynecologic malignancy, typically develops in younger women with the average age of onset at around 45 years.
   - The second most frequent cancer in women above 50 years old (after breast cancer)
   - Most commonly detected by routine cytological test (Papanicolaou smear screening)
   - Risk factors:
     - human papilloma virus - HPV (16 and 18) infection – *sexually transmitted disease*
     - multiple sexual partners
     - early age of first sexual intercourse
   - Clinical presentation:
     - vaginal bleeding
     - vaginal discharge
     - subclinical with an abnormality detected on Pap smear screening
   - Histological types:
     - squamous cell carcinoma of the cervix: accounts for the vast majority (80-90%) of cases and is associated with exposure to human papilloma virus (HPV)
     - adenocarcinoma of the cervix: ~ 5-20%
     - small cell carcinoma of the cervix: rare (0.5-6%)
     - adeno-squamous cell carcinoma of the cervix: rare
- Little usefulness of US, CT (detecting only more advanced stages)
- MRI is recommended imaging method to detect, determine the size and direction of spread of the tumor
- Both MRI and CT are used in evaluation of metastatic lymph nodes
Diseases of the female reproductive system

Tumors of ovaries

- Relatively common and account for ≈ 6% of female malignancies
- The first cause of mortality from neoplasms of female reproductive organs
- Commonly asymptomatic; symptoms appear after tumor reaches a large size
- Very diverse in terms of histology and morphology (cystic, solid, mixed), may secrete hormones

Subtypes:

- Epithelial ovarian tumours: ~ 60-70% (serous tumors, mucinous tumors, endometrioid tumors, other)
- Germ cell ovarian tumors: ~ 20% (teratomas, dysgerminomas, yolk sac tumors, choriocarcinomas)
- Sex cord - stromal ovarian tumors: ~ 8-10%
- Mixed: uncommon (e.g. carcinosarcoma)
- Other
  - ovarian lymphoma
  - metastases to the ovary (Krukenburg tumor)
Serological tests: CA-125 levels elevated in most ovarian malignancies (~80% in general), AFP levels elevated particularly with immature ovarian teratomas (~50% of cases) and ovarian yolk sac tumors.

Ultrasound (especially using transvaginal probe) is primary imaging modality in ovarian tumors. Simple ovarian cyst is easy to diagnose by US (round, well limited, single chamber); cysts with multi-compartmental, thickened walls and papillomatous growths indicate malignancy possibility.

CT and MRI – staging, recurrences.

Peritoneal metastases (also known as peritoneal carcinomatosis when extensive), which are most common in ovarian serous tumors, manifest themselves by:
- thickening and enhancement of peritoneum,
- soft tissue nodules,
- stranding and thickening of the omentum (omentum cake),
- stranding an distortion of the small bowel mesentery,
- ascites, especially if loculated.
Ovarian serous cystadenofibroma

Ovarian cancer (top) with peritoneal carcinomatosis (bottom)
Pathology of testis and epididymis

1. Hydrocele:
   - Congenital or acquired (by trauma, epididymitis, testicular torsion, testicular neoplasm) serous fluid collection within layers of the tunica vaginalis. It is the most common form of testicular enlargement.
   - Clinically – a progressing painless scrotal mass.
   - Ultrasound is the first modality usually used to evaluate hydroceles. It presents as a simple fluid collection surrounding the testis. It is avascular on Doppler evaluation. It may contain septations or calcifications (hematoma or empyema remnants). A funiculocele (bottom picture) is a sub type of hydrocele, however, it doesn't surround the testis. They can also appear larger with straining (Valsalva).
   - On MRI, signal characteristics of the hydroceles are typical to fluid: T1WI - low signal, T2WI - high signal.
Diseases of the male reproductive system

Pathology of testes and epididymides

2. Epididymitis and orchitis

- Inflammation of the epididymis, and may be associated with inflammation extending to the testis itself, in which case the term **epididymo-orchitis** is used. This should be distinguished from isolated orchitis which is by comparison much less common.
- Two peaks of prevalence: under 2 years of age and over 6 years of age.
- The clinical spectrum ranges from mild tenderness to a severe febrile process with acute unilateral scrotal pain.
- Diagnosed by ultrasound:
  - The epididymal head is the most affected region, and reactive hydrocele and wall thickening are frequently present.
  - Increased size and, depending on the time of evolution, decreased, increased, or heterogeneous echogenicity of the affected organ are usually observed.
  - The inflammation produces increased blood flow within the epididymis, testis, or both.
  - Analysis of the epididymal Doppler waveform may reveal a low-resistance pattern as compared with the normal pattern.
Diseases of the male reproductive system

Pathology of testes and epididymides

3. Testicular torsion

- It occurs when a testicle torts on the spermatic cord resulting in the cutting off of blood supply.
- The most common symptom is acute unilateral testicular pain.
- The diagnosis is often made clinically but if it is in doubt an ultrasound is helpful.
- The key findings of a torted testis in US include:
  - increase in size of the testis and epididymis
  - homogenous echotexture (early finding, prior to necrosis), later heterogenous echotexture (a late finding - after 24 hours, hypoechoic regions imply necrosis)
  - altered blood flow (in incomplete torsion elevated resistive index - RI > 0.75, in complete torsion absence of blood flow in both the testis and epididymis)
  - reactive hydrocoele
  - reactive thickening of the scrotal skin with hyperaemia and increased flow on Color Doppler examination
Diseases of the male reproductive system

Pathology of testes and epididymides

4. Testicular tumors

- the most common neoplasms in men between the ages of 20 and 34.
- primary tumors: 94% of all tumors:
  - testicular germ cell tumors: 90% of primary tumors (seminoma, non-seminomatous germ cell tumors - embryonal cell carcinoma, choriocarcinoma, yolk sac tumor, teratoma, mixed germ cell tumor)
  - testicular non-germ cell tumor: 10% of primary tumors (Sertoli cell tumor, Leydig cell tumor)
- secondary tumors: 6% of all tumors (lymphoma, leukaemia, metastases to testis)
- Symptoms: gradually growing tumor of the scrotum, usually painless, sometimes associated with a slight injury.
- Ultrasound and a physical examination serve as a basis for diagnosis
- CT and MRI: in doubtful cases, to assess the extent of the tumor and lymph node enlargement. Chest CT is often performed to detect possible metastases to the lungs.
Diseases of the male reproductive system

Pathology of testes and epididymides

5. Varicocele

- A dilatation of pampiniform plexus of veins, a network of many small veins found in the male spermatic cord.
- The estimated incidence is at ~ 15% of general male population and ~ 40% of sub-fertile and infertile men (most common cause of correctable male infertility).
- Most varicoceles are primary and result from incompetent or congenitally absent valves in the testicular vein (internal spermatic vein). Secondary varicoceles are much less common and result from increased pressure in testicular vein due to compression (e.g. extrinsic mass), obstruction (e.g. renal vein thrombus) or splenorenal shunting (portal hypertension).
- Can be asymptomatic, if present symptoms include scrotal mass, scrotal swelling, scrotal pain, testicular atrophy, infertility or subfertility.
- Ultrasound (diagnostic investigation of choice): dilatation of pampiniform plexus veins >3 mm diameter, characteristically a serpiginous appearance, flow reversal with the Valsalva manoeuvre, Doppler ultrasound can be used to grade the degree of reflux
- CT may show dilated enhancing serpiginous veins
- MRI - dilated enhancing serpiginous veins incidentally noted during scrotal MR, signal intensity depends on velocity of flow (low flow: intermediate T1 and high T2, high flow: signal void), enhancement following gadolinium administration
- Venography - only performed during endovascular treatment, may show dilated testicular veins and retrograde flow of contrast towards the scrotum
Imaging in obstetrics
Imaging in obstetrics

- Principle: restrict imaging methods to studies the least harmful to the mother and fetus.
  - Do not perform radiological procedures in the first trimester, unless it is absolutely necessary.
  - Absolutely avoid X-ray and CT examinations of the abdominal organs, pelvis and lumbar spine in pregnancy.
  - If it is possible, use ultrasound or MRI instead!
Role of ultrasound in obstetrics

- Determining the gestational age
- Evaluation of the development and position of the fetus
- Finding multiple pregnancy
- Determining the cause of bleeding during pregnancy
- Assessment of the conditions to perform amniocentesis, as well as amniotic fluid volume assessment
- Confirmation of fetal death
- Diagnosis of fetal malformations
- Detection of cervical incompetence

A 9 weeks twin pregnancy

A 3D/4D ultrasound selfie!
Safety of ultrasound in pregnancy

- The occurrence of undesirable consequences in children who underwent prenatal ultrasound examination, had not been reported yet.
- Ultrasound waves, unlike X-rays, do not ionize matter.
- However, they can do damage to cells through thermal or mechanical interactions.
- Therefore, ultrasound should not be used more than is recommended (in Poland, 3-4 examinations during pregnancy) – application of ALARA (As Low As Reasonably Achievable) rule.
- The Doppler modes should not be used in fetal ultrasound unless necessary (higher energy, more thermal effects on tissues).
MRI during pregnancy

- Limited to cases where the life or health of the mother or the fetus is at risk, and other imaging methods have failed or did not answer the clinical doubts.
- So far, there was no reported influence of the magnetic field intensities applied in the MRI on cells development and differentiation.
- However, it should be avoided until necessary, especially at first trimester.
- MRI is helpful in monitoring intrauterine fetal development; the shape, location, and malformations of the uterus are very well visible in MRI.
- Dedicated tools allow to perform prenatal surgery, for example, in the case of hydrocephalus.
CT during pregnancy

- Little use during pregnancy due to ionizing radiation.
- In practice, restricted only to the last weeks of pregnancy to assess the dimensions of the pelvis and measuring the size of the fetus (more accurate and much less harmful to the mother and fetus than previously performed X-ray pelvimetry).