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INTERVENTIONAL DIAGNOSTIC METHODS IN MAMMOLOGY

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Abstract. Interventional diagnostic methods in mammology represent a group of minimally invasive procedures performed under imaging guidance to obtain cellular or tissue samples for the morphological verification of breast lesions. The relevance of this topic is обусловлена the high global prevalence of breast cancer and the need for timely and accurate diagnosis to determine the optimal treatment strategy. The aim of this review is to analyze contemporary domestic and international studies focused on interventional diagnostic methods in mammology, as well as to assess their diagnostic effectiveness and safety profile.

Materials and methods included an analysis of publications from scientific databases such as PubMed, eLibrary, and CyberLeninka over recent years. The review incorporates original clinical studies, randomized controlled trials, systematic reviews, and meta-analyses.

The results indicate that core needle biopsy is considered the “gold standard” for preoperative morphological verification of breast lesions due to its high sensitivity and specificity, reaching 95–98%. Vacuum-assisted biopsy allows for the collection of a larger volume of tissue and demonstrates high diagnostic accuracy, particularly in cases involving microcalcifications and high-risk lesions. MRI-guided biopsy is used for lesions visualized exclusively by magnetic resonance imaging and is characterized by high technical success rates and a low false-negative rate. The safety profile of interventional methods is generally favorable. The most common complications include minor bleeding and hematoma formation, whereas severe complications are extremely rare. Pain is typically mild to moderate and depends on the technique used and individual patient characteristics. Thus, interventional diagnostic methods in mammology are highly effective and safe tools that play a key role in the modern diagnosis of breast diseases. At the same time, further standardization of approaches and multicenter studies are required to optimize diagnostic algorithms.

Keywords: mammology, mammography, computed tomography, magnetic resonance imaging, interventional method.

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МАММОЛОГИЯДАҒЫ ИНТЕРВЕНЦИЯЛЫҚ ДИАГНОСТИКАЛЫҚ ӘДІСТЕР

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Аңдатпа. Маммологиядағы интервенциялық диагностика әдістері сүт безінің патологиялық өзгерістерін морфологиялық верификациялау үшін жасушалық немесе тіндік материал алу мақсатында көзбен шолып бақылаумен орындалатын аз инвазивті араласулар тобын білдіреді. Тақырыптың өзектілігі сүт безі обырының бүкіл әлемде кең таралуымен және емдеудің оңтайлы тактикасын таңдау үшін уақтылы диагностикалау қажеттілігімен байланысты. Осы шолудың мақсаты маммологиядағы интервенциялық диагностика әдістеріне арналған қазіргі заманғы отандық және шетелдік зерттеулерді талдау, сондай-ақ олардың диагностикалық тиімділігі мен қауіпсіздігін бағалау болып табылады.

Материалдар мен әдістер соңғы жылдары PubMed, eLibrary және CyberLeninka ғылыми дерекқорларында ұсынылған жарияланымдарды талдауды қамтыды. Шолуға бірегей клиникалық зерттеулер, рандомизацияланған бақыланатын зерттеулер, жүйелі шолулар мен метаанализдер енгізілген.

Нәтижелер 95-98% -ға жететін жоғары сезімталдық пен ерекшеліктің арқасында сүт безінің ошақтарын операция алдындағы морфологиялық верификацияның «алтын стандарты» болып табылатынын көрсетті. Вакуум-ассистирленген биопсия тіннің үлкен көлемін алуды қамтамасыз етеді және жоғары диагностикалық дәлдікті көрсетеді, әсіресе микрокальцинаттар мен жоғары қауіп ошақтары болған кезде. МРТ-бағытталатын биопсия тек магниттік-резонанстық томография кезінде ғана визуалданатын ошақтар кезінде қолданылады және жоғары техникалық табыстылықпен және жалған теріс нәтижелердің төмен жиілігімен сипатталады. Интервенциялық әдістердің қауіпсіздік бейіні қолайлы болып табылады. Ең жиі асқынулар шамалы қан кетулер мен гематомалар болып табылады, ал ауыр асқынулар өте сирек кездеседі. Ауырсыну синдромы, әдетте, қалыпты көрінеді және қолданылатын әдістемеге және пациенттің жеке ерекшеліктеріне байланысты болады. Осылайша, маммологиядағы интервенциялық диагностика әдістері сүт безі ауруларын қазіргі заманғы диагностикалауда негізгі рөл атқаратын тиімділігі жоғары және қауіпсіз құралдар болып табылады. Сонымен бірге диагностикалық алгоритмдерді оңтайландыру үшін тәсілдерді одан әрі стандарттау және көп орталықтық зерттеулер жүргізу талап етіледі.

Түйінді сөздер: маммология, маммография, компьютерлік томография, магнитті-резонанстық томография, интервенциялық әдіс.

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ИНТЕРВЕНЦИОННЫЕ МЕТОДЫ ДИАГНОСТИКИ В МАММОЛОГИИ

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Аннотация. Интервенционные методы диагностики в маммологии представляют собой группу малоинвазивных вмешательств, выполняемых под визуальным контролем с целью получения клеточного или тканевого материала для морфологической верификации патологических изменений молочной железы. Актуальность темы обусловлена высокой распространённостью рака молочной железы во всём мире и необходимостью своевременной диагностики для выбора оптимальной тактики лечения. Целью данного обзора является анализ современных отечественных и зарубежных исследований, посвящённых интервенционным методам диагностики в маммологии, а также оценка их диагностической эффективности и безопасности.

Материалы и методы включали анализ публикаций, представленных в научных базах данных PubMed, eLibrary и CyberLeninka за последние годы. В обзор включены оригинальные клинические исследования, рандомизированные контролируемые исследования, систематические обзоры и метаанализы.

Результаты показали, что кор-биопсия является «золотым стандартом» предоперационной морфологической верификации очагов молочной железы благодаря высокой чувствительности и специфичности, достигающим 95–98%. Вакуум-ассистированная биопсия обеспечивает забор большего объёма ткани и демонстрирует высокую диагностическую точность, особенно при наличии микрокальцинатов и очагов повышенного риска. МРТ-направляемая биопсия применяется при очагах, визуализируемых исключительно при магнитно-резонансной томографии, и характеризуется высокой технической успешностью и низкой частотой ложноотрицательных результатов. Профиль безопасности интервенционных методов является благоприятным. Наиболее частыми осложнениями являются незначительные кровотечения и гематомы, тогда как тяжёлые осложнения встречаются крайне редко. Болевой синдром, как правило, выражен умеренно и зависит от используемой методики и индивидуальных особенностей пациента. Таким образом, интервенционные методы диагностики в маммологии являются высокоэффективными и безопасными инструментами, играющими ключевую роль в современной диагностике заболеваний молочной железы. В то же время требуется дальнейшая стандартизация подходов и проведение многоцентровых исследований для оптимизации диагностических алгоритмов.

Ключевые слова: маммология, маммография, компьютерная томография, магнитно-резонансная томография, интервенционный метод.

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Introduction. Interventional diagnostic methods in mammology are minimally invasive, visually guided breast interventions performed to obtain cellular or tissue material for subsequent morphological examination. According to the American College of Radiology (ACR), interventional methods include fine needle aspiration biopsy, core biopsy, vacuum-associated biopsy/excision, as well as stereotactic, ultrasound and MRI guided interventions used on an outpatient basis [5]. The clinical purpose of this type of diagnosis is to describe the characteristics of the tumor and affected lymph nodes for the purpose of subsequent planning of organ—preserving treatment and systemic therapy [21]. The relevance of the topic is determined by the high global burden of breast cancer, where millions of new cases are registered annually, which requires the availability and standardization of interventional methods for timely morphological verification and personalization of treatment [36].

The purpose of the study. Based on current domestic and foreign works, to study interventional diagnostic methods in mammology, their effect on the human body, as well as their effectiveness.

Materials and methods. In the course of this work, we analyzed domestic and foreign publications presented in the scientific databases Elibrary, PubMed and Cyberleninka mainly over the past five years, and also summarized the data obtained by the authors on the topic we are investigating. The inclusion criteria were: publication type — domestic and foreign original clinical trials, randomized controlled trials (RCTs), systematic reviews and meta-analyses published in international peer-reviewed journals. The exclusion criteria were: letters to the editor, brief annotations without data provided, conference materials without the full version of the article, studies not directly related to interventional diagnostic methods and/or mammology.

Results. *Populations and objects of biopsy.*

According to Advani S.S. et al., middle-aged and older women predominate in modern cohorts of patients referred for image-guided breast biopsy. According to the Consortium for Breast Cancer Surveillance. (Breast Cancer Surveillance Consortium, BCSC) among the elderly, the median age is about 73 years [1]. Mammographic density, determined by the Breast Imaging Reporting and Data System (BI-RADS), according to ACR, describes the proportion of fibroglandular tissue and is a key characteristic of the population, influencing both the risk and the choice of a biopsy guidance method [16]. According to a meta–analysis of 42 studies, high density increases the risk of breast cancer by approximately 1.8-4.6 times compared with low density [26]. Dense tissue masks the foci and reduces the sensitivity of mammography, which requires the use of alternative imaging and appropriate biopsy techniques [17]. In these cases, the European Society for Breast Radiology recommends MRI screening [24]. The objects of biopsy depend on the modality: on mammography, these are masses, architectural distortions and microcalcifications, and on MRI, focus, mass and non—mass gain [11]. Stereotactic and tomosynthesis-guided CT biopsy are the methods of choice for microcalcifications and fine mammographic abnormalities without a sonographic correlate [34]. For MR-exclusive lesions, an MRI guided biopsy is the standard [28]. The localization of foci is heterogeneous. So, according to Chen J.H. et al., the highest incidence of malignant lesions is observed in the upper-right quadrant [13]. Microcalcinates predominate in stereotactic biopsy arrays, most objects belong to BI-RADS 4, and the proportion of malignancy is about 30% in individual series [4].
Methods of interventional interventions.

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In modern reviews, a core biopsy (CNB) is considered the basic method of morphological verification of breast foci [23]. A core biopsy is usually performed with a 14G needle [12]. According to the clinical recommendations of the European Society of Medical Oncology (ESMO), a CT biopsy provides the determination of immunohistochemical markers ER, PR, HER2 and Ki-67 [21]. The typical volume of sampling during a core biopsy is 3-5 columns of tissue [8]. Vacuum-assisted biopsy (VAB) uses larger calibres - 9-11 G, and allows to take a significantly larger volume of tissue [38]. In a randomized trial, according to Zhang Y. et al., 10G CNB showed higher accuracy and lower frequency of underestimation compared to 14G CNB with a comparable safety profile [20]. In microcalcifications, stereotactic/tomosynthesis-guided VAB with a 9-11 G needle demonstrates a high frequency of calcinate extraction and low underestimation rates [15]. According to Dekker B.M. et al., for a reliable conclusion, the optimal volume of samples at 9G VAB is 6-9 samples [19]. According to Kim H.S. et al., if microcalcinates are visualized on ultrasound, vacuum-assisted biopsy under ultrasound guidance is an effective alternative to stereotactic access [5] (Fig. 1)

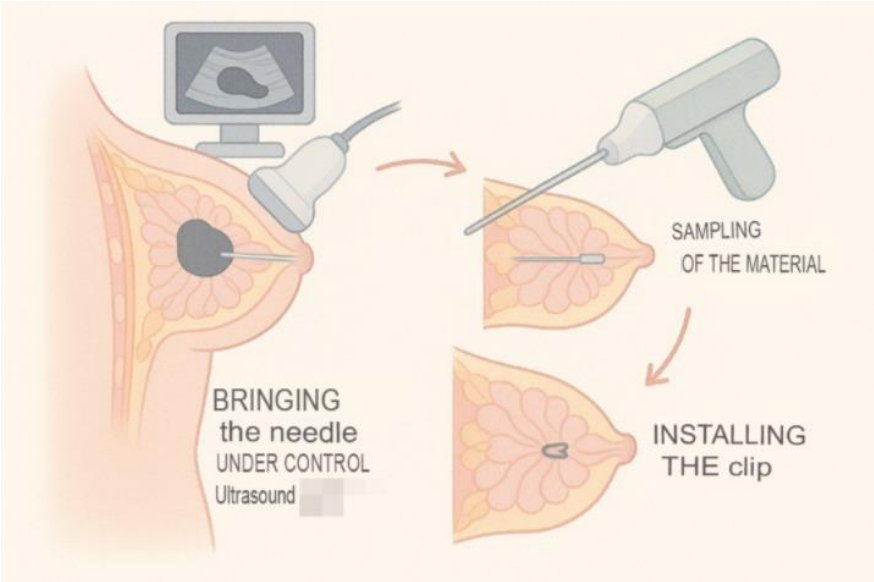

Figure 1. The scheme of material intake.

Diagnostic effectiveness of interventional diagnostic methods.

According to Sauer G. et al., the volume of material obtained during corbiography is high enough. Thus, in large batches, the proportion of insufficient samples did not exceed 0.4%, which directly affects accuracy and reduces the need for repeated interventions [32]. Ziegler-Rodriguez G.J. notes that the overall diagnostic effectiveness of corbiopsy remains at the level of high sensitivity and specificity (about 95-98%), ensuring correct stratification of patients during pre-therapeutic assessment [39]. According to Boba M. et al.. False negative results for corbiography are on the order of 2-4%, depending on the technique and concordance of the X-ray-pathomorphological correlation, while the specificity is close to 100% [9]. In the work of Özcan B.B. et al. It is claimed that MR-guided biopsies have a high technical success rate of about 99% and an extremely low false negative percentage of about 0.75% [28]. According to Lu W. et al., vacuum-assisted biopsy demonstrates high sensitivity, about 98% [22].

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Special clinical cases.

According to Bick U. et al., microcalcinates without accompanying mass are subject to stereotactic or tomosynthesis-guided vacuum-assisted biopsy in order to maximize calcinate extraction and reduce underestimation of high-risk foci and DCIS [8]. So, Liberman L. Et al. note that directional 11G vacuum-assisted biopsy demonstrates a high frequency of calcinate extraction and diagnostic effectiveness in mammographic abnormalities [20]. If microcalcifications are confidently visualized on ultrasound, a vacuum-assisted biopsy under ultrasound guidance, according to Kim H.S. It is also an effective alternative to stereotactic access [19]. According to Özcan B.B. et al., for foci visible only on MRI, the accepted approach is MR-guided biopsy, characterized by a low proportion of false negative results [28]. If the MR lesion is not contrasted on the day of the intervention, according to the work of Niketa C. et al., short-term MR follow-up with a second biopsy attempt is recommended with reperfusion of the lesion or the appearance of suspicious signs [27].

With regard to B3 pathologies, European interdisciplinary guidelines allow vacuum-assisted excision as an alternative to open biopsy in selected cases, subject to selection criteria and quality control [31]. The guidelines of specialized surgical societies specify that VAB is advisable for individual B3 foci up to 15 mm as an intermediate strategy [6].

Multifocal and multicentric lesions are determined by the presence of several foci in the same quadrant or in different quadrants, respectively, which affects the volume of surgery and requires advanced imaging and careful correlation of biopsy data [25]. These forms are described in the Avera E results. They are more often associated with unfavorable biological characteristics and a worse prognosis compared to unifocal tumors [7]. The sensitivity of standard imaging techniques for detecting multifocality and multicentrism is variable, which justifies the use of MRI and multipath navigation when selecting targets for biopsy [10].

Safety and complications.

Percutaneous breast biopsies are minimally invasive and generally safe procedures. The most common adverse events, according to Bick U. and others - minor bleeding, whereas infectious complications are extremely rare [38]. According to modern studies and reviews, the total frequency of bleeding after biopsies reaches about 10.9%, however, clinically significant hematomas requiring prolonged compression or intervention are significantly less common [37]. In large prospective series, most hematomas are small and clinically insignificant, requiring no specific treatment [14]. Severe vascular complications after vacuum-assisted biopsy are casuistically rare, but cases of massive hematomas successfully treated with endovascular embolization have been described [29]. Pneumo- or hemopneumothorax after percutaneous interventions for foci adjacent to the chest wall are described as isolated cases and are considered extremely rare events [33]. The pain response during most interventions is assessed as mild; An increase in pain intensity is associated with a larger needle gauge, an increase in the number of passages, and preoperative anxiety in the patient [35] (Table 1).

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Table 1. Comparative characteristics of pain sensitivity in different types of interventional methods

Method	Assessment of pain sensitivity, according to the visual-analog pain scale	Author
Core biopsy	2.0 – 5.8 - average	Zagouri F. and co-author.[38]
Vacuum-assisted interventions	4.35 ± 1.70 - average	Soon A.E. and co-authors. [1] Zagouri F. And co-author. [2]
Open excision biopsy	9.15 ± 0.74 - high	Soo A.E. and co-authors [1]

Discussion. Despite the widespread use of percutaneous methods, the evidence base remains heterogeneous. Thus, according to Rubio I.T. et al., controversial issues remain regarding the indications of vacuum-assisted excision and surgical excision for B3-lesia [31]. Reporting on complications and risk factors is fragmentary and often does not allow analyzing the impact of patient, focal, and procedural factors [2]. For MR-guided biopsy, meta-analyses confirm high technical success and a low false negative percentage, but according to Özcan B.B. et al., observation strategies after a benign concordant response vary between centers and require unification in the form of risk-based algorithms [28]. Contrast-enhanced mammography as a guidance platform is developing rapidly, but issues of dose loading, diagnostic efficacy, and comparative safety in relation to stereotaxis and tomosynthesis remain research priorities [3]. Modern reviews by the authors emphasize the need for multicenter protocols for corbiography with unification of indications, techniques and endpoints, including economics and acceptability for the patient [18,31,30,39].

Conclusions. Thus, based on the analysis of domestic and foreign publications, it has been established that visually guided interventional methods, primarily corbiography, provide high diagnostic effectiveness with a favorable safety profile and are the standard of pre-therapeutic verification. Vacuum-assisted interventions are justified for microcalcifications and individual B3 pathologies, and routine clip-tag installation and X-ray-pathological correlation increase the accuracy and controllability of subsequent tactics. At the same time, standardization of outcomes, multicenter prospective navigation comparisons and randomized VAE trials against surgical excision, as well as unification of follow-up after benign MR biopsy are required.

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