

## Reference

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**WIRELESS CAPSULE ENDOSCOPY: A TECHNOLOGICAL LEAP TOWARD REPLACING TRADITIONAL ENDOSCOPIC METHODS****W. H. Amhaz<sup>1</sup>, M. F. S. H. Al-Kamali<sup>2</sup>**<sup>1</sup> *Gomel State Medical University, Republic of Belarus*<sup>2</sup> *Sukhoi State Technical University of Gomel, Republic of Belarus*

*Wireless capsule endoscopy has transformed gastrointestinal diagnostics by offering a non-invasive method for imaging the small intestine. Utilizing intelligent algorithms, capsule robots can detect lesions and initiate therapeutic interventions, enhancing clinical outcomes.*

**Keywords:** wireless capsule endoscopy, gastrointestinal diagnostics, intelligent algorithms, lesion detection, therapeutic interventions.

**БЕСПРОВОДНАЯ КАПСУЛЬНАЯ ЭНДОСКОПИЯ: ТЕХНОЛОГИЧЕСКИЙ СКАЧОК К ЗАМЕНЕ ТРАДИЦИОННЫХ ЭНДОСКОПИЧЕСКИХ МЕТОДОВ****В. Х. Амхаз<sup>1</sup>, М. Ф. С. Х. Аль-Камали<sup>2</sup>**<sup>1</sup> *Гомельский государственный медицинский университет, Республика Беларусь*<sup>2</sup> *Гомельский государственный технический университет имени П. О. Сухого, Республика Беларусь*

*Беспроводная капсульная эндоскопия преобразила диагностику заболеваний желудочно-кишечного тракта, предложив неинвазивный метод визуализации тонкого кишечника. Используя интеллектуальные алгоритмы, капсульные роботы могут обнаруживать поражения и инициировать терапевтические вмешательства, улучшая клинические результаты.*

**Ключевые слова:** беспроводная капсульная эндоскопия, диагностика заболеваний желудочно-кишечного тракта, интеллектуальные алгоритмы, обнаружение поражений, терапевтические вмешательства.

Wireless capsule endoscopy (WCE) has revolutionized gastrointestinal imaging by employing high-resolution cameras that capture thousands of images as the capsule traverses the digestive tract. Once ingested, the capsule is propelled by peristalsis, wirelessly transmitting images to an external recording device for analysis. This procedure typically lasts several hours, allowing patients to resume normal activities, thus minimizing discomfort and disruption.

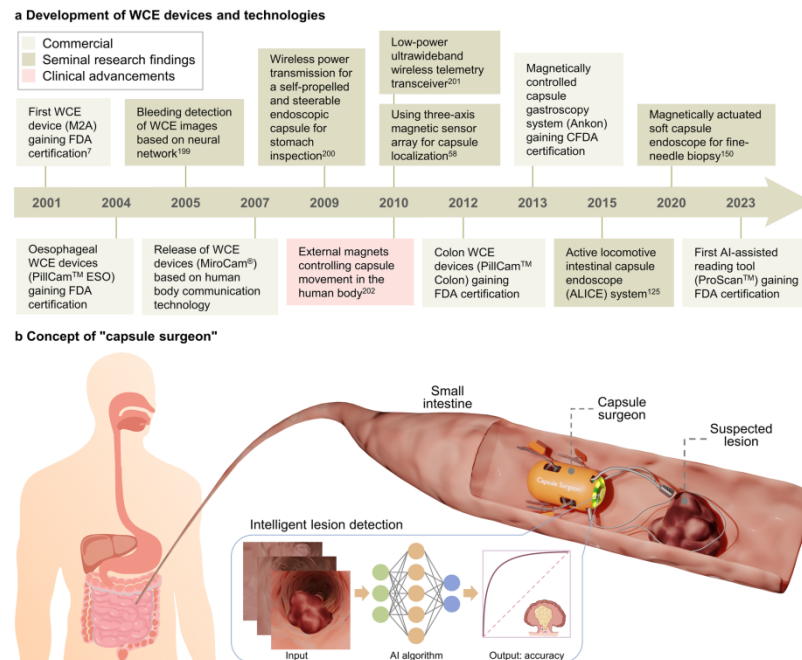
WCE offers several advantages over conventional endoscopy. It is minimally invasive, eliminating the need for anesthesia and surgical instruments, which significantly reduces patient risk and discomfort. The panoramic view provided by WCE enhances visualization of the small intestine – a region often difficult to assess using traditional methods. Its capacity to capture images from multiple angles facilitates detailed evaluation of mucosal lesions, polyps, and bleeding sites, promoting higher patient compliance.

Real-time data acquisition is another critical benefit of WCE, as it transmits images instantly, allowing for immediate assessment and faster clinical decision-making. Recent studies highlight advancements in ingestible electronic devices for diagnostic and therapeutic applications, focusing on key components like sensors and integrated circuits. Our research complements these findings by exploring the “capsule surgeon” concept, emphasizing intelligent robotics and AI-based lesion detection.

WCE technology has evolved from a mere “gastrointestinal video recorder” to a “controllable diagnostic capsule robot”. This evolution is supported by developments in multidisciplinary fields, including artificial intelligence and microelectromechanical systems (MEMS), leading to the emergence of smart capsule robots. While most testing has been confined to animal models, the clinical application of these technologies holds significant promise.

To further develop WCE, attention must be paid to the challenges of multidisciplinary integration. Technical compatibility is crucial, particularly in minimizing interference among various magnetic field-based technologies. For instance, simultaneous operation of wireless power transmission and magnetic actuators can lead to inconsistencies in magnetic field control. Pre-simulation of these scenarios and exploration of magnetic field separation methods are essential for successful implementation.

Another challenge is the technological complexity inherent in integrating multiple functionalities within capsule robots. Achieving high integration while maintaining a compact design is vital. Current capsule designs often occupy substantial space, making them difficult to swallow. Utilizing a single propulsion system for multiple functions, such as magnetic propulsion, could simplify designs and reduce size.



*Fig. 1.* Wireless capsule endoscopy:

- a* – Progression of Wireless Capsule Endoscopy (WCE) This timeline outlines the commercial evolution, key research breakthroughs, and clinical advancements of WCE devices from 2001 to 2023, highlighting the roles of the FDA and CFDA;
- b* – Concept of the “Capsule Surgeon” Utilizing intelligent detection algorithms, the capsule robot identifies lesions and can initiate therapeutic actions with components like snares and electrotomes

Telemedicine has gained traction, especially during the COVID-19 pandemic, enabling remote patient management. By leveraging mobile cloud support and 5G connectivity, this model can be applied to capsule robots, enhancing access to diagnostic and therapeutic services, particularly in underserved regions.

Finally, expanding the therapeutic functions of capsule robots is imperative. Currently, they are primarily used for diagnostics and limited therapeutic applications, such as biopsies and drug delivery. Integrating capabilities for endoscopic mucosal resection (EMR) and endoscopic submucosal resection (ESD) into capsule designs could significantly enhance their clinical utility. The potential of medical micro/nanorobots in various therapeutic roles suggests a future where larger WCE robots serve as “warships” while micro/nanorobots act as “soldiers”, performing intricate tissue manipulation tasks, thereby exploring previously inaccessible areas of the gastrointestinal tract.

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Wireless capsule endoscopy marks a transformative approach in gastrointestinal diagnostics, with ongoing advancements that promise to enhance its capabilities and integration into clinical practice. Addressing technical challenges and expanding therapeutic functions will be crucial for realizing the full potential of this promising technology.

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## РЕЗОНАНС-ТРАНСФОРМАТОРЫ

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*Рассмотрены методы расчета резонансных трансформаторов непрерывного и импульсного действия. На основе методов контурных токов, кусочно-линейной аппроксимации и операторного метода получены аналитические выражения для ключевых параметров. Результаты применимы в импульсной энергетике, медицинской диагностике и лазерных технологиях.*

**Ключевые слова:** резонансные трансформаторы, трансформаторы Тесла, метод контурных токов, кусочно-линейная аппроксимация, операторный метод, импульсная энергетика.

## RESONANCE TRANSFORMERS

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*The report discusses methods for calculating resonant transformers of continuous and pulsed action. Analytical expressions for key parameters are obtained based on the methods of contour currents, piecewise linear approximation and the operator method. The results are applicable in pulse energy, medical diagnostics and laser technologies.*

**Keywords:** resonant transformers, Tesla transformers, contour current method, piecewise linear approximation, operator method, pulse power engineering.