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Медицина є прикладом інтеграції багатьох наук. Наукові дослідження у сучасній медицині на основі досягнень фізики, хімії, біології, інформатики та інших наук відкривають нові можливості для вивчення процесів, які відбуваються в живих організмах, та вимагають якісних змін у підготовці медиків. Науково-практична інтернет-конференція «**Розвиток природничих наук як основа новітніх досягнень у медицині**» покликана змінювати свідомость людей, характер їхньої діяльності та стимулювати зміни у підготовці медичних кадрів. Вміле застосування сучасних природничо-наукових досягнень є запорукою подальшого розвитку медицини як галузі знань.

Конференція присвячена висвітленню нових теоретичних і прикладних результатів у галузі природничих наук та інформаційних технологій, що є важливими для розвитку медицини та стимулювання взаємодії між науковцями природничих та медичних наук.

Комп'ютерна верстка:
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У збірнику подані матеріали науково-практичної інтернет-конференції «Розвиток природничих наук як основа новітніх досягнень у медицині». У статтях та тезах представлені результати теоретичних і експериментальних досліджень.

Матеріали подаються в авторській редакції. Відповідальність за достовірність інформації, правильність фактів, цитат та посилань несуть автори.

Для наукових та науково-педагогічних співробітників, викладачів закладів вищої освіти, аспірантів та студентів.

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Modern Instrumental Examination Methods in Gastroenterology: From Theory to Practice

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Abstract. Novel advances in instrumental diagnostic in gastroenterology are provided. Progress in basic sciences as a background for developing new diagnostic methods is discussed. Diagnostic tests widely used abroad but with a limited application in Ukraine for diagnosing pathology of the esophagus, intestines, liver and gall bladder are defined.

Keywords. Gastroenterology, Modern Instrumental Examination Methods.

Recent dramatic scientific and technological progress and its' consequences, digitalisation and computerization, brought many advantages and help to integrate achievements and knowledge on physiology, cell and molecular biology, physics and biochemistry to routine clinical practice.

Despite, physical classical methods of patient investigation remain actual, instrumental tests provide wide spectrum of important diagnostic information that couldn't be collected remotely, "from surface". Even more, new investigations with much better specificity, sensitivity and possibility are implemented and well-known physiological data become a platform for creating modern testing technologies. Despite that, spectrum of instrumental tests in routine clinical practice of the Ukrainian gastroenterologist remains quite limited, including radiological techniques (ultrasound, X-ray with and without contrasting agents, CT scans, MRI etc) and endoscopic procedures (fibroesophagogastroduodenoscopy, colonoscopy, rectoscopy).

Investigation of the esophagus. Twenty-four-hour pH impedance testing is a procedure that assesses acid and non-acid reflux in the esophagus from the stomach over a 24-hour period. 24-hour pH impedance testing is a gold standard procedure for diagnosing GERD, and is performed in order to determine whether reflux of stomach contents into the esophagus is causing symptoms such as heartburn, regurgitation, cough or sore throat. Classic pH metry revealed a number of limitations: even a drop of acid decreasing a pH of sensor below 4.0 is enough for positive testing, and improperly plasced sensor will also not detec changes if they occurred on another level. but it gives no information about the height of reflux, number of episodes, therefore does not help in relating patient's symptoms to esophagus health. Twenty-four-hour pH impedance testing recognizes any reflux episode and determins its composition (acid, weakly acid, basic, neutral), duration, location and nature (solid, liquid, gaseous, mixed). This exam is an important evolution in 24-hour esophageal pH monitoring. Impedance is the inverse of conductivity; it varies with the chemical and physical nature of the bolus, and displays direction and transit of the bolus (including refluxes and gas). The impedance is measured by the specific 6-channel sensor and its value changes with the passage of the bolus and reflux, identifying its “direction” [1].

The physiology of the digestive tract includes the study of the pharyngeal motility, the esophagus and its sphincters, upper and lower ones. Recently, this physiological event got in focus of gastroenterologists being studied with the HRM (High Resolution Esophageal Manometry) [3]. It provides precision and ease of diagnosis never achieved before. The HRM exam is performed by the transnasal introduction of a catheter with a number of sensors. Is allows a complete study of the swallowing phase while keeping the probe in the same position, and helps to obtain information about complete and coordinated results of all degenerative and peristaltic activity. HRM is a useful tool for detecting reduction of the basal tone of the lower esophageal Sphincter; spontaneous transient releases and delayed gastric emptying, resulting in increased intragastric pressure; alterations in esophageal peristalsis, which causes reduced ability in the cleaning of refluxed material.

Investigation of the stomach and intestines. Random sampling of mucosa for biopsyhas during routine endoscopy been a primary method used for surveillance. This approach has been ineffective, time-consuming, expensive and has low diagnostic yield. This has led to a more focused approach, taking targeted biopsies of any mucosal abnormalities using dye-based chromoendoscopy, virtual chromoendoscopy or a combination of dye-based chromoendoscopy with high magnification imaging. Chromoendoscopy is a modified gastrointestinal endoscopy procedure that uses stains, pigments or dyes to locate cancerous spots, erosions or other lesions in the lining (mucosa) of patient’s digestive tract [7]. Spraying of dyes to improve characterization of the mucosa resulting in selective uptake (vital staining: methylene blue, Lugol's solution) or enhancement of mucosal surface pattern (contrast staining: indigo carmine, acetic acid) provides vital information by using a special imaging modality. Chromoendoscopy has important implications for the detection, demarcation and characterisation of dysplasia. The procedure is safe and provides important clinical information which eventually leads to better treatment options. Compared with other imaging techniques such as fluorescent spectroscopy, chromoendoscopy can be easier, safer and less expensive.

Classic chromoendoscopy means visual evaluation of stained linings. Application of it together with high-definition imaging technologies helps to avoid subjective mistakes or underestimation. Novel imaging techniques such as virtual (or electronic) chromoscopy use optical contrast imaging for mucosal inspection and polyp detection and as a substitute for dye-based chromoscopy. Virtual chromoscopy is an imaging modality designed for enhancing the mucosal surface or superficial capillaries network by applying different spectrals of light. For example, narrow-band imaging is a technique where ambient light of a blue and green wavelengths are used to highlight detail, particularly of vascular structures. It has the advantage requiring only a change in light source, and is less cumbersome than instillation of dye. A similar technique to narrow-band imaging using blue and green filters has been used in endoscopes manufactured by Fujinon, termed Fuji Intelligent Chromoendoscopy (FICE).

Autofluorescence (light-induced fluorescence endoscopy (LIFE) is another imaging technique that uses ultraviolet and short-wavelength light into tissue molecules resulting in the emission of fluorescence light and was developed for detecting mucosal tissue derangements associated with neoplastic changes. This technology thus far has been useful for detecting dysplastic lesions in long-standing chronic inflammatory bowel disease. Another interesting imaging technique under evaluation is probe-based confocal laser endomicroscopy (pCLE), which allows in vivo imaging of tissue at micrometer resolution and is designed to be a substitute for histologic analysis. In a recent study, pCLE was compared to virtual chromoscopy for classification of colon polyps and was found to have a higher sensitivity with similar specificity [2]. With enhanced capability of morphologic assessment, these novel techniques might be capable of replacing histopathology for nondepressed, diminutive lesions but are not precise enough to detect adenomatous changes and neoplasia, which would obviate the need for biopsies and formal pathologic assessment.

Elastic scattering spectroscopy (ESS) typically harnesses light scattered in the backward direction (toward incident light) and can encompass a wide range of wavelengths. Elastic scattering is driven by spatial variations of tissue refractive index (determined by local macromolecular density) and thus provides fundamental insights into the size distribution of tissue structures. ESS has shown excellent discrimination between hyperplastic vs adenomatous tissue (84% sensitivity and 84% specificity)

Other techniques that can enhance detail of mucosa include confocal microscopy, magnification endoscopy and optical coherence tomography.

Despite duodenum and colon are widely examined in routine ukrainian gastroenterology, small intestines remain tabula rasa for diagnostic procedures, That is maintained by great length of the organ – over 5 meters, small diameter (abound 2.5 cm - 1 inch) and difficulties for access. But, enteroscopy is already applied in a number of countries. That is a type of endoscopy that allows to examine the small intestine (small bowel) and treat issues at the same time. There are several techniques a gastroenterologist may use to gain access deep into the small intestine, including video capsule endoscopy, double balloon enteroscopy, single balloon enteroscopy and spiral enteroscopy. Balloon enteroscopy and spiral enteroscopy are collectively known as deep enteroscopy.

Double Balloon Enteroscopy is also called push-and-pull enteroscopy or balloon-assisted enteroscopy. It uses a flexible endoscope with a camera that is placed inside a wider tube. A gastroenterologist guides both tubes into the small intestine. Each tube has a balloon on one end. Alternately inflating and deflating the balloons and carefully pushing and pulling, the doctor can gather up the small intestine onto the outer tube, one section at a time, almost like gathering a curtain onto a curtain rod or pushing a sleeve up on arm.Compacting the length of the small intestine makes it easier for the inner endoscopy tube to access the entire length of the small bowel and treat problems.

Single Balloon Enteroscopy, a simplified version of the double balloon procedure, uses one balloon instead of two. Motorized Spiral Enteroscopy uses a special tube with a rotating spiral placed over the endoscope, which allows the scope to move back and forth in the small intestine as the spiral rotates. A small motor is attached to the spiral so the doctor can control when to engage the spinning mechanism. Spiral enteroscopy works similar to balloon enteroscopy, but it uses the spiral instead of balloons to help advance the scope. Like balloon enteroscopy, spiral enteroscopy can go deep into the small bowel. The Food and Drug Administration has not been approved spiral enteroscopy for use in the United States.

Anorectal manometry. This test helps determine the strength of the muscles in the rectum and anus. These muscles normally tighten to hold in a bowel movement and relax when a bowel movement is passed. Anorectal manometry is helpful in evaluating anorectal malformations and Hirschsprung disease, among other problems. A small tube is placed into the rectum to measure the pressures exerted by the sphincter muscles that ring the canal.

Investigation of gall bladder and bile ducts. A spectrum of radiological methods widely used abroad includes a hepatobiliary iminodiacetic acid (HIDA) scan, also known as cholescintigraphy or hepatobiliary scintigraphy. It is a well-known imaging procedure used to diagnose problems of the liver, gallbladder and bile ducts. HIDA scans were introduced over 40 years ago but remained underappreciated for a while. Several years ago, attention of investigators was driven to this method again. It was demonstrated, that in symptomatic patients with no ultrasound markers of gall bladder disease, HIDA scan may be useful in up to 94% cases.

An injected chemical called a radioactive tracer (radiotracer) and a nuclear medicine scanner - gamma camera are required for the testing so it is mostly available in big clinical centers and clinics. Scanner tracks the flow of the tracer from patient’s liver into gallbladder and small intestine and creates computer images. Healthcare providers use a HIDA scan to help diagnose and evaluate the following conditions: acute and chronic cholecystitis, objective confirmation of biliary dyskinesias, sphincter of Oddi dysfunction in partial; biliary atresia and biliary leak.

Current issue in **hepatology** as well as in other fields of medicine is an investigation of non-invasive diagnostical methods. In this regardance valuable achievements were gained in last decades. Wide implementation of transient elastography, computed tomography, magnetic resonance imaging, magnetic resonance elastography improves significantly diagnosis, staging and surveillance of hepatic diseases. A novel and promising instrumental method here is multispectral optoacoustic tomography (MSOT) - the technique which provides detection of ultrasound waves that are induced by thermo-elastic expansion of tissue upon absorption of light by various light absorbing biomolecules [5]. This technique based on non-ionizing energy avoids the use of contrast agents and provides the possibility for frequent measurements in individuals if needed [6]. In experimental studies by Huang S et al., have showed the ability of MSOT imaging to detect and distinguish all grades of steatosis, supporting its value for the management of disease progression and treatment efficacy monitoring in a preclinical model [5]. Huang Y et al., have tested the abovementioned optoacoustic technology for experimental diagnosing of drug-induced liver injury with positive conclusions. It was revealed that elevated expression of hepatic leucine aminopeptidase as a result of drug-induced liver injury cleaves the leucyl moiety and causes the red-shift of the probe's absorption band, thereby generating prominent optoacoustic signals for MSOT imaging. What is more, by rendering stacks of cross-sectional images as maximal intensity projection images, the authors could precisely locate the focus of drug-induced liver injury in mice [4]. One more study of the possibilities of MSOT in drug-induced liver injury early detection was performed by Zhang C and coauthors [9]. The authors have developed a superoxide anion activated MSOT for early diagnosis of drug-induced liver injury [8]. The temporal and spatial information received by three-dimensional MSOT images could also reveal the site and size of liver injury as the result of herbal medicine induced liver injury. Further investigations are needed to apply these methods in clinical settings. One of the limitations of this method to be applied in clinical practice is relatively small imaging depth, which is not sufficient for analysing a whole liver. This occurs due to the spectrum impairment in deep tissue. Since liver is rich in blood, a strong absorber for the wavelengths used, the excitation light is quickly exhausted in liver tissue [5]. However, encouraging results were obtained by Reber J et al, who with the help of MSOT significantly distinguish white adipose tissue and brown adipose tissue in healthy individuals. Also, these authors investigated MSOT to enable non-invasive imaging of brown adipose tissue activation [6]

Conclusion. Clinical instrumental investigations in modern gastroenterology are result of joined efforts of physics, chemists, IT-technology. Some opportunities that seemed to be fantastic some years ago are reality now. Further investigations are carries out to improve existing technologies and approaches and to develop new ones.

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