

Bölüm 12

BEYİN AMELİYATLARINDA İNTRAOPERATİF ULTRASON KULLANIMI



Bariş ERDOĞAN¹

GİRİŞ

Günümüzde daha önce yapılamayan ve yapılamaz denilen cerrahi müdahaleler daha düşük mortalite ve morbite ile yapılabilmektedir. Bunun bir nedeni artan anatomi bilgisi ve tecrübesi iken diğer esas neden ise teknolojiye yeniliklerdir. Bu bölümde intraoperatif ultrason kullanımını hakkında bilgi verilecektir.

ULTRASON

Tarihçe

Ses dalgaları ile ilk çalışmalar milattan önceki bir döneme Pisagora kadar dayanmaktadır. Daha sonra Aristo'nun bazı çalışmaları takip etmiştir. Milattan sonra Galileo tarafından da bazı çalışmalar yapılsa da Cruie kardeşlerin keşfi modern çağda ultrasonun temelini oluşturur. Cruie kardeşler Rochelle veya kuvars tuzu kristallerine basınç uygulandığında bir elektrik yükü oluştuğunu gözlemlediler ve kendisine uygulanan kuvvetle bu yükün doğru orantılı olduğunu gördüler. Bu duruma Yunanca baskı anlamına gelen piezoelektrik olarak isimlendirdiler. Günümüz ultrason sistemleri elektrik ve mekanik enerjiyi birbirine

dönüştürmek için piezoelektrik kristallerini kullanır. Piezoelektrik 4 khz ile 200 khz arasında çalışabilir (1-3).

İNTRAOPERATİF ULTRASON KULLANIMI

İntrakraniyal patolojiler geniş spektruma sahip farklı klinik bulgularla kendini gösterir. İntrakraniyal patolojileri tedavisinde hastaya zarar vermeden mevcut lezyonun total çıkarılması hedeflenmektedir. Hastaya minimum zarar verip maksimum fayda sağlamak için teknolojiyi kullanmak gerekir. Sadece preoperatif dönemde değil intraoperatif dönemde de teknolojiye ihtiyaç vardır. İntraoperatif olarak yararlandığımız teknolojik araçlardan bir tanesi de ultrasondur.

İntraoperatif ultrason kullanımını diğer görüntüleme tekniklerine göre ucuzdur, lezyonun kesin konumunu verir ancak oryantasyon için eğitim gerekir. Anatomik yer işaretleri ve bunların varyantlarının tam olarak belirlenmesi, lezyonların boyutlarının lokalizasyonu ve tasviri yapılarak hastaya uygulanacak cerrahi prosedürün planlanmasında ve yürütülmesinde kritik öneme sahiptir (4). İntraoperatif ilk olarak 1930 yılında Dussik

¹ Uzm. Dr., Şanlıurfa Eğitim ve Araştırma Hastanesi Beyin ve Sinir Cerrahisi Bölümü dr.baris.erdogan@gmail.com

KAYNAKLAR

- Beg S, Parra-Blanco A, Rangunath K. Optimising the performance and interpretation of small bowel capsule endoscopy. *Frontline Gastroenterol.* 2018;9(4):300-308. Doi: 10.1136/flgastro-2017-100878.
- Nakajima F, Furumatsu Y, Yurugi T, et al. Investigation of small intestinal lesions in dialysis patients using capsule endoscopy. *Hemodial Int.* 2019;23(1):77-80. Doi: 10.1111/hdi.12683.
- Trigo Salado C, Leo Carnerero E, de la Cruz Ramírez. Crohn's disease and cystic fibrosis: there is still a lot to learn. *Rev Esp Enferm Dig.* 2018;110(12):835-836. Doi: 10.17235/reed.2018.5725/2018.
- Kim SH, Yang DH, Kim JS. Current Status of Interpretation of Small Bowel Capsule Endoscopy. *Clin Endosc.* 2018 ;51(4):329-333. .Doi: 10.5946/ce.2018.095
- Mitselos IV, Christodoulou DK. What defines quality in small bowel capsule endoscopy. *Ann Transl Med.* 2018;6(13):260. Doi: 10.21037/atm.2018.05.28
- Chetcuti Zammit S, Sanders DS, Sidhu R. A comprehensive review on the utility of capsule endoscopy in coeliac disease: From computational analysis to the bedside. *Comput Biol Med.* 2018;102:300-314. Doi: 10.1016/j.compbio.2018.06.025.
- Petroniene R, Dubcenco E, Baker JP, et al. Given capsule endoscopy in celiac disease: evaluation of diagnostic accuracy and interobserver agreement. *Am J Gastroenterol* 2005; 100:685-94. doi: 10.1111/j.1572-0241.2005.41069.x.
- Culliford A, Daly J, Diamond B, et al. The value of wireless capsule endoscopy in patients with complicated celiac disease. *Gastrointest Endosc* 2005; 62:55. Doi: 10.1016/s0016-5107(05)01566-x.
- Cellier C, Green PH, Collin P, et al. ICCE consensus for celiac disease. *Endoscopy* 2005; 37:1055.
- Cobrin GM, Pittman RH, Lewis BS. Increased diagnostic yield of small bowel tumors with capsule endoscopy. *Cancer* 2006; 107:22-7. Doi: 10.1002/cncr.21975.
- Gastineau S, Viala J, Caldari D, et al. Contribution of capsule endoscopy to Peutz-Jeghers syndrome management in children. *Dig Liver Dis* 2012; 44:839-43. doi: 10.1016/j.dld.2012.05.018.
- Akin E, Demirezer Bolat A, Buyukasik S, et al. Comparison between Capsule Endoscopy and Magnetic Resonance Enterography for the Detection of Polyps of the Small Intestine in Patients with Familial Adenomatous Polyposis. *Gastroenterol Res Pract* 2012;215028. Doi: 10.1155/2012/215028
- Haanstra JF, Al-Toma A, Dekker E, et al. Prevalence of small-bowel neoplasia in Lynch syndrome assessed by video capsule endoscopy. *Gut* 2015;64:1578-83. Doi: 10.1136/gutjnl-2014-307348.
- Stanich PP, Kleinman B, Betkerur K, et al. Video capsule endoscopy is successful and effective in outpatients with implantable cardiac devices. *Dig Endosc* 2014; 26:726-30. Doi: 10.1111/den.12288.
- Bandorski D, Höltingen R, Stunder D, et al. Capsule endoscopy in patients with cardiac pacemakers, implantable cardioverter defibrillators and left heart assist devices. *Ann Gastroenterol* 2014; 27:3-8.
- Cuschieri JR, Osman MN, Wong RC, et al. Small bowel capsule endoscopy in patients with cardiac pacemakers and implantable cardioverter defibrillators: Outcome analysis using telemetry review. *World J Gastrointest Endosc* 2012; 4:87-93. Doi: 10.4253/wjge.v4.i3.87.
- Bandorski D, Jakobs R, Brück M, et al. Capsule Endoscopy in Patients with Cardiac Pacemakers and Implantable Cardioverter Defibrillators: (Re)evaluation of the Current State in Germany, Austria, and Switzerland 2010. *Gastroenterol Res Pract* 2012; 717408. Doi:10.1155/2012/717408
- Enns RA, Hookey L, Armstrong D, et al. Clinical Practice Guidelines for the Use of Video Capsule Endoscopy. *Gastroenterology* 2017;152:497-514. Doi: 10.1053/j.gastro.2016.12.032.
- Chen HB, Huang Y, Chen SY, et al. Small bowel preparations for capsule endoscopy with mannitol and simethicone: a prospective, randomized, clinical trial. *J Clin Gastroenterol* 2011; 45:337-41. Doi: 10.1097/MCG.0b013e3181f0f3a3.
- Esaki M, Matsumoto T, Kudo T, et al. Bowel preparations for capsule endoscopy: a comparison between simethicone and magnesium citrate. *Gastrointest Endosc* 2009; 69:94-101. Doi: 10.1016/j.gie.2008.04.054.
- Albert J, Göbel CM, Lesske J, et al. Simethicone for small bowel preparation for capsule endoscopy: a systematic, single-blinded, controlled study. *Gastrointest Endosc* 2004; 59:487-91. Doi: 10.1016/s0016-5107(04)00003-3.
- Wei W, Ge ZZ, Lu H, et al. Purgative bowel cleansing combined with simethicone improves capsule endoscopy imaging. *Am J Gastroenterol* 2008; 103:77-82. Doi: 10.1111/j.1572-0241.2007.01633.x.
- Selby W. Complete small-bowel transit in patients undergoing capsule endoscopy: determining factors and improvement with metoclopramide. *Gastrointest Endosc* 2005; 61:80-5. Doi: 10.1016/s0016-5107(04)02462-9.
- Almeida N, Figueiredo P, Freire P, et al. The effect of metoclopramide in capsule enteroscopy. *Dig Dis Sci* 2010; 55:153-7. Doi: 10.1007/s10620-008-0687-y.
- Holden JP, Dureja P, Pfau PR, et al. Endoscopic placement of the small-bowel video capsule by using a capsule endoscope delivery device. *Gastrointest Endosc* 2007; 65:842-7. Doi: 10.1016/j.gie.2007.01.033
- Zwinger LL, Siegmund B, Stroux A, et al. CapsoCam SV-1 Versus PillCam SB 3 in the Detection of Obscure Gastrointestinal Bleeding: Results of a Prospective Randomized Comparative Multicenter Study. *J Clin Gastroenterol* 2019; 53:e101. Doi: 10.1097/MCG.0000000000000994.
- Lewis BS, Swain P. Capsule endoscopy in the evaluation of patients with suspected small intestinal bleeding: Results of a pilot study. *Gastrointest Endosc* 2002; 56:349-53. Doi: 10.1016/s0016-5107(02)70037-0.
- Delvaux MM, Saurin JC, Gaudin JL, et al. Comparison of wireless endoscopic capsule and push-enteroscopy in patients with obscure occult/overt digestive bleeding:

- Results of a prospective, blinded, multicenter trial (abstract). *Gastrointest Endosc* 2002; 55:AB88.
29. Van Gossum A, Francois E, Schmit A, et al. A prospective comparative study between push-enteroscopy and wireless video capsule in patients with obscure digestive bleeding (abstract). *Gastrointest Endosc* 2002; 55:AB88.
 30. Costamagna G, Shah SK, Riccioni ME, et al. A prospective trial comparing small bowel radiographs and video capsule endoscopy for suspected small bowel disease. *Gastroenterology* 2002; 123:999-1005. Doi: 10.1053/gast.2002.35988.
 31. Beejay UA, Haber GB, Rasul I, et al. A pilot trial comparing the diagnostic utility and reproducibility of Given diagnostic imaging system to conventional enteroscopy in the evaluation of chronic obscure gastrointestinal bleeding (abstract). *Am J Gastroenterol* 2002; 97:S299.
 32. Mergener K, Schembr DB, Brandabur JJ, et al. Clinical utility of capsule endoscopy—a single center experience (abstract). *Am J Gastroenterol* 2002; 97:S299.
 33. Katz DZ, Lewis BS. Capsule endoscopy in known or suspected Crohn's disease: The perspective of the referring physician and the patient (abstract). *Am J Gastroenterol* 2002; 97:S300.
 34. Cave DR, Chen W, Pratt D, et al. Detection of small intestinal varices by capsule endoscopy (abstract). *Am J Gastroenterol* 2002; 97:S302.
 35. Smith MA, Mergener K, Schembr DB, et al. Complications and problems with capsule endoscopy (abstract). *Am J Gastroenterol* 2002; 97:S301.
 36. Scapa E, Jacob H, Lewkowicz S, et al. Initial experience of wireless-capsule endoscopy for evaluating occult gastrointestinal bleeding and suspected small bowel pathology. *Am J Gastroenterol* 2002; 97:2776-9. doi: 10.1111/j.1572-0241.2002.07021.x.
 37. Liao Z, Gao R, Xu C, Li ZS. Indications and detection, completion, and retention rates of small-bowel capsule endoscopy: a systematic review. *Gastrointest Endosc* 2010; 71:280-6. Doi: 10.1016/j.gie.2009.09.031.
 38. Ell C, Remke S, May A, et al. The first prospective controlled trial comparing wireless capsule endoscopy with push enteroscopy in chronic gastrointestinal bleeding. *Endoscopy* 2002; 34:685-9. Doi:10.1055/s-2002-33446.
 39. Hartmann D, Schmidt H, Bolz G, et al. A prospective two-center study comparing wireless capsule endoscopy with intraoperative enteroscopy in patients with obscure GI bleeding. *Gastrointest Endosc* 2005; 61:826-32. Doi: 10.1016/s0016-5107(05)00372-x.
 40. Laine L, Sahota A, Shah A. Does capsule endoscopy improve outcomes in obscure gastrointestinal bleeding? Randomized trial versus dedicated small bowel radiography. *Gastroenterology* 2010; 138:1673-80. Doi: 10.1053/j.gastro.2010.01.047.
 41. Park JJ, Cheon JH, Kim HM, et al. Negative capsule endoscopy without subsequent enteroscopy does not predict lower long-term rebleeding rates in patients with obscure GI bleeding. *Gastrointest Endosc* 2010; 71:990-7. Doi: 10.1016/j.gie.2009.12.009.
 42. Koulaouzidis A, Yung DE, Lam JH, et al. The use of small-bowel capsule endoscopy in iron-deficiency anemia alone; be aware of the young anemic patient. *Scand J Gastroenterol* 2012; 47:1094-1100. Doi:org/10.3109/00365521.2012.704938
 43. Lepileur L, Dray X, Antonietti M, et al. Factors associated with diagnosis of obscure gastrointestinal bleeding by video capsule endoscopy. *Clin Gastroenterol Hepatol* 2012; 10:1376-80. Doi: 10.1016/j.cgh.2012.05.024.
 44. Triester SL, Leighton JA, Leontiadis GI, et al. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with obscure gastrointestinal bleeding. *Am J Gastroenterol* 2005; 100:2407-18. Doi: 10.1111/j.1572-0241.2005.00274.x.
 45. Pennazio M, Santucci R, Rondonotti E, et al. Outcome of patients with obscure gastrointestinal bleeding after capsule endoscopy: report of 100 consecutive cases. *Gastroenterology* 2004; 126:643-53. Doi: 10.1053/j.gastro.2003.11.057.
 46. Koulaouzidis A, Rondonotti E, Giannakou A, et al. Diagnostic yield of small-bowel capsule endoscopy in patients with iron-deficiency anemia: a systematic review. *Gastrointest Endosc* 2012; 76:983-92. Doi: 10.1016/j.gie.2012.07.035.
 47. Laine L, Sahota A, Shah A. Does capsule endoscopy improve outcomes in obscure gastrointestinal bleeding? Randomized trial versus dedicated small bowel radiography. *Gastroenterology* 2010; 138:1673-80. Doi: 10.1053/j.gastro.2010.01.047.
 48. Liangpunsakul S, Chadalawada V, Rex DK, et al. Wireless capsule endoscopy detects small bowel ulcers in patients with normal results from state of the art enteroclysis. *Am J Gastroenterol* 2003;98:1295-8. Doi:10.1111/j.1572-0241.2003.07471.x.
 49. Triester SL, Leighton JA, Leontiadis GI, et al. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with non-stricturing small bowel Crohn's disease. *Am J Gastroenterol* 2006; 101:954-64. doi: 10.1111/j.1572-0241.2006.00506.x.
 50. Kornbluth A, Colombel JF, Leighton JA, et al. ICCE consensus for inflammatory bowel disease. *Endoscopy* 2005; 37:1051-4. doi: 10.1055/s-2005-870315.
 51. Fireman Z, Mahajna E, Broide E, et al. Diagnosing small bowel Crohn's disease with wireless capsule endoscopy. *Gut* 2003; 52:390-2. Doi: 10.1136/gut.52.3.390.
 52. Herrerías JM, Caunedo A, Rodríguez-Téllez M, et al. Capsule endoscopy in patients with suspected Crohn's disease and negative endoscopy. *Endoscopy* 2003; 35:564-8. Doi: 10.1055/s-2003-40241.
 53. Chong AK, Taylor A, Miller A, et al. Capsule endoscopy vs. push enteroscopy and enteroclysis in suspected small-bowel Crohn's disease. *Gastrointest Endosc* 2005; 61:255-61. Doi: 10.1016/s0016-5107(04)02571-4.
 54. Cheifetz AS, Kornbluth AA, Legnani P, et al. The risk of retention of the capsule endoscope in patients with known or suspected Crohn's disease. *Am J Gastroenterol* 2006; 101:2218-22. doi: 10.1111/j.1572-0241.2006.00761.x.
 55. Kopylov U, Yablecovitch D, Lahat A, et al. Detection of Small Bowel Mucosal Healing and Deep Remission

- in Patients With Known Small Bowel Crohn's Disease Using Biomarkers, Capsule Endoscopy, and Imaging. *Am J Gastroenterol* 2015; 110:1316-23. Doi: 10.1038/ayg.2015.221.
56. Rondonotti E, Spada C, Cave D, et al. Video capsule endoscopy in the diagnosis of celiac disease: a multicenter study. *Am J Gastroenterol* 2007; 102:1624-31. Doi: 10.1111/j.1572-0241.2007.01238.x.
 57. Hakim FA, Alexander JA, Huprich JE, et al. CT-enterography may identify small bowel tumors not detected by capsule endoscopy: eight years experience at Mayo Clinic Rochester. *Dig Dis Sci* 2011; 56:2914-9. Doi: 10.1007/s10620-011-1773-0.
 58. Min M, Noujaim MG, Green J, et al. Role of Mucosal Protrusion Angle in Discriminating between True and False Masses of the Small Bowel on Video Capsule Endoscopy. *J Clin Med* 2019; 27;8(4):418. Doi: 10.3390/jcm8040418.
 59. Clarke JO, Giday SA, Magno P, et al. How good is capsule endoscopy for detection of periampullary lesions? Results of a tertiary-referral center. *Gastrointest Endosc* 2008;68(2):267-72. doi: 10.1016/j.gie.2007.11.055.
 60. Xue M, Chen X, Shi L, et al. Small-bowel capsule endoscopy in patients with unexplained chronic abdominal pain: a systematic review. *Gastrointest Endosc* 2015;81(1):186-93. Doi: 10.1016/j.gie.2014.04.062.
 61. Marya NB, Jawaid S, Foley A, et al. A randomized controlled trial comparing efficacy of early video capsule endoscopy with standard of care in the approach to nonhematemesis GI bleeding (with videos). *Gastrointest Endosc* 2019;89(1):33-43.e4. Doi: 10.1016/j.gie.2018.06.016.
 62. Rezapour M, Amadi C, Gerson LB. Retention associated with video capsule endoscopy: systematic review and meta-analysis. *Gastrointest Endosc* 2017;85(6):1157-1168.e2. Doi: 10.1016/j.gie.2016.12.024.
 63. Rozendorn N, Klang E, Lahat A, et al. Prediction of patency capsule retention in known Crohn's disease patients by using magnetic resonance imaging. *Gastrointest Endosc* 2016 ;83(1):182-7. doi: 10.1016/j.gie.2015.05.048.
 64. Delvaux M, Ben Soussan E, Laurent V, et al. Clinical evaluation of the use of the M2A patency capsule system before a capsule endoscopy procedure, in patients with known or suspected intestinal stenosis. *Endoscopy* 2005 37(9):801-7. Doi: 10.1055/s-2005-870241.
 65. Boivin ML, Lochs H, Voderholzer WA. Does passage of a patency capsule indicate small-bowel patency? A prospective clinical trial? *Endoscopy* 2005;37(9):808-15. Doi: 10.1055/s-2005-870220.
 66. Spada C, Spera G, Riccioni M, et al. A novel diagnostic tool for detecting functional patency of the small bowel: the Given patency capsule. *Endoscopy* 2005;37(9):793-800. Doi: 10.1055/s-2005-870246.
 67. Koornstra JJ, Weersma RK. Agile patency system. *Gastrointest Endosc* 2009;69(3):602-3. Doi:10.1016/j.gie.2008.06.042.
 68. Eliakim R, Sharma VK, Yassin K, et al. A prospective study of the diagnostic accuracy of PillCam ESO esophageal capsule endoscopy versus conventional upper endoscopy in patients with chronic gastroesophageal reflux diseases. *J Clin Gastroenterol* 2005; 39(7):572-8. Doi: 10.1097/01.mcg.0000170764.29202.24.
 69. Colli A, Gana JC, Turner D, et al. Capsule endoscopy for the diagnosis of oesophageal varices in people with chronic liver disease or portal vein thrombosis. *Cochrane Database Syst Rev* 2014;(10):CD008760. doi: 10.1002/14651858.CD008760.pub2.
 70. Lin OS, Schembre DB, Mergener K, et al. Blinded comparison of esophageal capsule endoscopy versus conventional endoscopy for a diagnosis of Barrett's esophagus in patients with chronic gastroesophageal reflux. *Gastrointest Endosc* 2007 ;65(4):577-83. Doi: 10.1016/j.gie.2006.06.035.
 71. Bhardwaj A, Hollenbeak CS, Pooran N, Mathew A. A meta-analysis of the diagnostic accuracy of esophageal capsule endoscopy for Barrett's esophagus in patients with gastroesophageal reflux disease. *Am J Gastroenterol* 2009; 104(6):1533-9. Doi: 10.1038/ajg.2009.86.
 72. Rubenstein JH, Inadomi JM, Brill JV, Eisen GM. Cost utility of screening for Barrett's esophagus with esophageal capsule endoscopy versus conventional upper endoscopy. *Clin Gastroenterol Hepatol* 2007;5(3):312-8. Doi: 10.1016/j.cgh.2006.12.08.
 73. Gerson L, Lin OS. Cost-benefit analysis of capsule endoscopy compared with standard upper endoscopy for the detection of Barrett's esophagus. *Clin Gastroenterol Hepatol* 2007; 5(3):319-25. Doi: 10.1016/j.cgh.2006.12.022.
 74. Sacher-Huvelin S, Calès P, Bureau C, et al. Screening of esophageal varices by esophageal capsule endoscopy: results of a French multicenter prospective study. *Endoscopy* 2015; 47(6):486-92. Doi: 10.1055/s-0034-1391393.
 75. Meltzer AC, Ali MA, Kresiberg RB, et al. Video capsule endoscopy in the emergency department: a prospective study of acute upper gastrointestinal hemorrhage. *Ann Emerg Med* 2013; 61(4):438-443.e1. Doi: 10.1016/j.annemergmed.2012.11.008.
 76. Chandran S, Testro A, Urquhart P, et al. Risk stratification of upper GI bleeding with an esophageal capsule. *Gastrointest Endosc* 2013; 77(6):891-8. Doi: 10.1016/j.gie.2013.01.003.
 77. Spada C, Hassan C, Bellini D, et al. Imaging alternatives to colonoscopy: CT colonography and colon capsule. *European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastrointestinal and Abdominal Radiology (ESGAR) Guideline - Update 2020. Endoscopy* 2020; 52(12): 1127-1141. Doi: 10.1055/a-1258-4819
 78. Schoofs N, Devière J, Van Gossum A. PillCam colon capsule endoscopy compared with colonoscopy for colorectal tumor diagnosis: a prospective pilot study. *Endoscopy* 2006; 38(10):971-7. Doi: 10.1055/s-2006-944835.
 79. Eliakim R, Yassin K, Niv Y, et al. Prospective multicenter performance evaluation of the second-generation colon capsule compared with colonoscopy. *Endoscopy* 2009;41(12):1026-31. Doi: 10.1055/s-0029-1215360.

80. Gay G, Delvaux M, Frederic M, Fassler I. Could the colonic capsule PillCam Colon be clinically useful for selecting patients who deserve a complete colonoscopy?: results of clinical comparison with colonoscopy in the perspective of colorectal cancer screening. *Am J Gastroenterol* 2010;105(5):1076-86. Doi: 10.1038/ayg.2009.624.
81. Rokkas T, Papaxoinis K, Triantafyllou K, Ladas SD. A meta-analysis evaluating the accuracy of colon capsule endoscopy in detecting colon polyps. *Gastrointest Endosc* 2010;71(4):792-8. Doi: 10.1016/j.gie.2009.10.050.
82. Spada C, Hassan C, Marmo R, et al. Meta-analysis shows colon capsule endoscopy is effective in detecting colorectal polyps. *Clin Gastroenterol Hepatol* 2010;8(6):516-22. Doi: 10.1016/j.cgh.2010.02.018.
83. Sacher-Huvelin S, Coron E, Gaudric M, et al. Colon capsule endoscopy vs. colonoscopy in patients at average or increased risk of colorectal cancer. *Aliment Pharmacol Ther* 2010;32(9):1145-53. Doi: 10.1111/j.1365-2036.2010.04458.x.
84. Spada C, Hassan C, Munoz-Navas M, et al. Second-generation colon capsule endoscopy compared with colonoscopy. *Gastrointest Endosc* 2011;74(3):581-589.e1. Doi: 10.1016/j.gie.2011.03.1125.
85. Rondonotti E, Borghi C, Mandelli G, et al. Accuracy of capsule colonoscopy and computed tomographic colonography in individuals with positive results from the fecal occult blood test. *Clin Gastroenterol Hepatol* 2014;12(8):1303-10. Doi: 10.1016/j.cgh.2013.12.027.
86. Rex DK, Adler SN, Aisenberg J, et al. Accuracy of capsule colonoscopy in detecting colorectal polyps in a screening population. *Gastroenterology* 2015;148(5):948-957.e2. Doi: 10.1053/j.gastro.2015.01.025.
87. Xia J, Xia T, Pan J, et al. Use of artificial intelligence for detection of gastric lesions by magnetically controlled capsule endoscopy. *Gastrointest Endosc* 2021;93(1):133-139.e4. Doi: 10.1016/j.gie.2020.05.027.
88. Dray X, Iakovidis D, Houdeville C, et al. Artificial intelligence in small bowel capsule endoscopy - current status, challenges and future promise. *J Gastroenterol Hepatol* 2021;36(1):12-19. Doi: 10.1111/jgh.15341.
89. Trasolini R, Byrne MF. Artificial intelligence and deep learning for small bowel capsule endoscopy. *Dig Endosc* 2021;33(2):290-297. Doi: 10.1111/den.13896.
90. Liao Z, Hou X, Lin-Hu EQ, et al. Accuracy of Magnetically Controlled Capsule Endoscopy, Compared With Conventional Gastroscopy, in Detection of Gastric Diseases. *Clin Gastroenterol Hepatol* 2016;14(9):1266-1273.e1. Doi: 10.1016/j.cgh.2016.05.013.
91. Wanga S, Huang Y, Hud Y et al. Detachable string magnetically controlled capsule endoscopy for detecting high-risk varices in compensated advanced chronic liver disease (CHESS1801): A prospective multicenter study. *The Lancet Regional Health - Western Pacific* 6 (2021) 100072. Doi: Doi.org/10.1016/j.lanwpc.2020.100072
92. Rahman I, Pioche M, Shim CS, et al. Magnetic-assisted capsule endoscopy in the upper GI tract by using a novel navigation system (with video). *Gastrointest Endosc* 2016 ;83(5):889-895.e1. Doi: 10.1016/j.gie.2015.09.015.
93. Shamsudhin N, Zverev VI, Keller H, et al. Magnetically guided capsule endoscopy. *Med Phys* 2017;44(8):e91-e111. Doi: 10.1002/mp.12299. Epub 2017 Jun 23.