GEORGIAN MEDICAL NEWS

ISSN 1512-0112

NO 7-8 (340-341) Июль-Август 2023

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper formats of the Agency of Medical Information of the Georgian Association of Business Press. Published since 1994. Distributed in NIS, EU and USA.

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

GEORGIAN MEDICAL NEWS
No 7 (340) 2023

Содержание:

GEORGIAN MEDICAL NEWS
No 7 (340) 2023

ADVANCEMENTS IN MINIMALLY INVASIVE SURGERY: A COMPREHENSIVE ANALYSIS OF ROBOTIC SURGERY, ENDOSCOPIC TECHNIQUES, AND NATURAL ORIFICE TRANSLUMENAL ENDOSCOPIC SURGERY (NOTES)

Zora Khan[1], Deepthi Krishna[2], Surya Shekhar Daga[3], Nitin Kumar Rastogih[4], Rekha MM[5], Komal Patel[6].

[1]*Tutor, Department of Nursing, IIMT University, Meerut, Uttar Pradesh, India.*

[2]*Associate Professor, Department of Ayurveda, Sanskrit University, Mathura, Uttar Pradesh, India.*

[3]*Professor, Department of Forensic Science, Vivekananda Global University, Jaipur, India.*

[4]*Associate Professor, Department of General Surgery, TeerthankerMahaveer University, Moradabad, Uttar Pradesh, India.*

[5]*Assistant Professor, Department of Chemistry & Biochemistry, School of Sciences, JAIN (Deemed-to-be University), Karnataka, India.*

[6]*Consultant, Department of Gynaecology, Parul University, PO Limda, Tal.Waghodia, District Vadodara, Gujarat, India.*

Abstract.

The term "Natural Orifice Transluminal Endoscopic Surgery" (NOTES) defines a surgical approach that leverages the body's natural orifices to access the abdominal cavity, presenting a patient-centric perspective by highlighting its potential to eliminate abdominal wall aggression, mitigate postoperative discomfort, and offer benefits comparable to laparoscopic surgery. This comprehensive paper aims to not only review the existing landscape of NOTES techniques but also to propose advancements in flexible tools augmenting established endoscopic platforms, while also exploring the revolutionary concept of robotic structures grounded in micromechatronics and communication technologies. The thorough analysis encompasses the assessment of advantages and limitations associated with flexible devices and robotic platforms, coupled with an in-depth evaluation of the current array of devices used in NOTES, informed by pertinent literature. The authors' comprehensive approach entails scrutinizing technological breakthroughs and offering viable solutions, fostering a comprehensive understanding. Furthermore, the study encompasses an exhaustive evaluation and juxtaposition of state-of-the-art NOTES devices, supplemented by a nuanced discourse on the merits and demerits of flexible devices and robotic platforms, with a focused emphasis on their inherent strengths and weaknesses. Within this context, the discourse extends to strategic suggestions aimed at refining extant designs and cultivating robust, dependable autonomous robotic platforms purpose-built for NOTES. This narrative encapsulates the multifaceted exploration of benefits, challenges, and potential remedies directed towards enhancing prevailing designs and forging a dependable foundation for the future of NOTES.

Key words. Laparoscopic surgery, flexible devices, natural orifice transluminal endoscopic surgery (notes), robotic.

Introduction.

Robotic surgery, natural orifice transluminal endoscopic surgery (NOTES), and endoscopic procedures have all revolutionised the minimally invasive surgery industry. Because of their potential to improve patient outcomes and surgical accuracy, these cutting-edge surgical procedures have attracted a lot of attention and become very popular [1]. Robotic systems are used in surgery to help surgeons carry out difficult procedures with greater dexterity and accuracy. The surgeons have more control and flexibility because to the robotic platforms, enabling complex manoeuvres and better visualization. Many surgical specialities, including urology, gynaecology, and general surgery, have adopted the technology [2]. On one hand, endoscopic methods use specialised tools and cameras to view and access the interior organs through tiny incisions. These methods have greatly decreased the necessity for open procedures, which has decreased trauma, sped up healing periods, and increased patient comfort. Surgery for the gastrointestinal, respiratory, and urinary systems frequently employs endoscopic techniques [3]. A NOTES surgical procedure, which is minimally invasive, combines therapeutic endoscopy with laparoscopy. By reaching the internal organs via natural orifices like the anus, vagina, or mouth, it strives to accomplish "scarless" surgery by obviating the necessity for exterior incisions. This cutting-edge method lessens the extent of the treatment and may provide advantages including reduced postoperative pain, a quicker recovery, and better cosmetic results has shown in figure 1.

A relatively recent technique called NOTES expands on minimally invasive surgery by entering the cavity in the abdomen through bodily passages like the vagina, mouth, or anus. NOTES strives to further minimise surgical stress, lessen postoperative discomfort, and improve cosmetic outcomes by doing away with the necessity for external incisions. In the NOTES, the vagina, mouth, urethra or anus, were used as natural orifices to access the abdomen cavity. minimally invasive surgical technique. Once a viscus, such as the bladder, colon, stomach, or vagina, has been punctured, the peritoneal cavity can be reached using a flexible endoscope. The surgical procedure was subsequently performed using standard endoscopic instruments through the endoscope's working channels. When compared to conventional laparoscopic surgery, NOTES offers benefits like better cosmetic outcomes, fewer anesthesia requirements, less discomfort, a speedier recovery, and a decreased incidence of wound-related issues [4]. After laparoscopy, NOTES was regarded as a possible major paradigm change in surgery. However, because it was still in its infancy, safety was still a major worry. The creation of suitable surgical equipment was essential for its effectiveness, as are ongoing clinical practice and assessment [5].

The article [6] described a robotic vaginal natural orifice transluminal endoscopic surgery (RvNOTES) using the humanoid-shaped Hominis Surgical device, a robot-assisted device. The first RvNOTES bilateral salpingo-oophorectomy

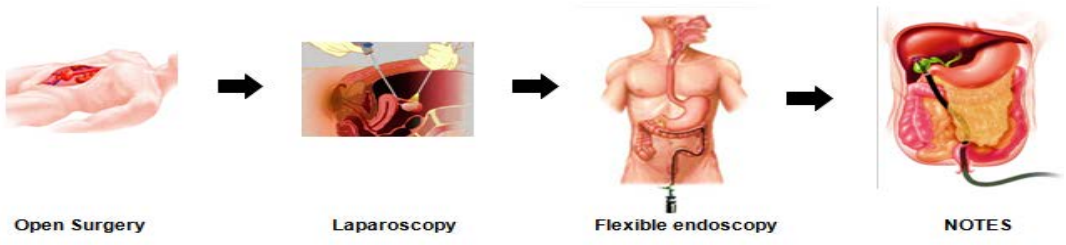

Figure 1. *Invasive surgery.*

(BSO) with the Hominis system was the main topic of the article, which highlights its benefits and potential as a different surgical strategy. The study emphasizes possible improvements in surgical precision by highlighting enhanced dexterity of Continuous robotics for cooperative natural aperture transluminal endoscopy with two manipulators. Despite its advantages, vaginal surgery was still not the accepted method of treatment. The article [7] was to compare traditional vNOTES surgery to robot-assisted transvaginal natural aperture transluminal surgical procedure surgery in order to determine its safety and viability. The emphasis was on comparing the potential benefits and results of R-vNOTES to the traditional T-vNOTES technique with regard to safety and viability. The study's findings, which demonstrate the viability of robotic aid in gynecological surgeries, include that robot-assisted transvaginal NOTES excision exhibits equivalent surgical outcomes as conventional transvaginal NOTES. In the article [8] used the Hominis surgical system to execute the first 30 robot vaginal natural orifice transluminal endoscopic surgery (RvNOTES) hysterectomies, which are detailed in the article. The conclusion is that benign gynecological problems can be successfully treated using robotic vaginal native orifice transluminal endoscopic hysterectomy. Evaluation of the viability and security of the unique robot-assisted method for RvNOTES operations was the main objective. The analysis and improvement of a novel collaborative use of two manipulators agility of continuum robot in cooperative environment are the main objectives of the article. They demonstrated possible improvements in surgical precision by demonstrating that collaborating dual-manipulator space improves the dexterity for natural opening surgery using transluminal endoscopes and ongoing robotics [9].

The dexterity function was evaluated using the low-Difference Jacobian matrix of a kinematic model. A unique adaptable parameters grey wolf coupled cuckoo optimization technique, which provides greater accuracy and faster convergence, was suggested to be used to optimize the objective function. According to experimental findings, the continuum robot has improved dexterity. The article [10] emphasized the features and benefits of vNOTES-H, emphasizing the need to explain its advantages and remove any obstacles to adoption in order to encourage its wider use. Due to its benefits, vaginal natural orifice transluminal endoscopic surgery hysterectomy (vNOTES-H) has several advantages, such as persistent visual guiding and the absence of abdominal skin incisions. was becoming more and more common. Due to particular equipment and expertise requirements, its introduction has been delayed in several Japanese regional core hospitals. The study concludes that the vNOTES hysterectomy has some advantages over the total laparoscopic hysterectomy. For patients with small uteruses, suggesting promising based on a retrospective examination, future possibilities at a central institution in the region. In the work [11] introduced the robotic natural orifice transluminal endoscopic surgery (NOTES), a revolutionary surgical approach for hysterectomy. The surgery promises to be gas-free and scar-free, with possible advantages for improved cosmetic results and decreased postoperative discomfort. The study concludes that robotic NOTES, the surgical procedure known as a hysterectomy leaves no scars and uses no gas, highlighting its potential advantages.

The research [12] compared traditional vNOTES (T-vNOTES) hysterectomy to robotically aided R-vNOTES surgery in order to determine its safety and viability. The evaluation of R-vNOTES's prospective benefits and results in comparison to the traditional T-vNOTES approach was the main objective. The study concludes that comparing surgical outcomes between robotic-assisted and traditional transvaginal natural orifice transluminal endoscopic surgery for hysterectomy highlights valuable insights in gynecological procedures. The study [13] examined the viability of carrying out robotic NOTES gynaecological procedures using a miniature single-site surgical robotic system. A real porcine animal model was used for the evaluation. The advantages of using robotic surgery include less trauma, quicker recovery, and higher patient satisfaction. However, the existing robotic systems utilized in NOTES gynaecology have drawbacks, such as arm collisions, countertraction difficulties, restricted area within the constrained pelvic anatomy, and limited tool dexterity. They indicated the successful implementation of robotic NOTES for using a pig model, hysterectomy and salpingo-oophorectomy, highlighting its feasibility and potential applicability.

For the surgical management of deeply infiltrating endometriosis (DIE), robotically assisted transvaginal NOTES must be performed in a safe manner, the study [14] shows the step-by-step procedures. The emphasis was on giving a thorough overview of the steps that make up the approach's procedural process. The study concludes that robotic vNOTES is a viable approach for resecting deeply infiltrated endometriosis involving parametrial and bowel tissues, demonstrating potential in gynecological procedures. In the research [15] utilized endoscopy and surgery. Robotics' potential applications are anticipated to increase with the adoption of therapeutic endoscopy. Artificial intelligence (AI) has many uses in endoscopic and surgical operations, including the detection, diagnosis, procedural support, identification of the dissection

plane, and prognosis of adverse events. By enhancing depth perception, 3D imaging improves both the optical and technical components of these treatments. The study's findings suggest that integrating AI, three-dimensional imagery, and NOTES will advance robotic endoscopy and help to shape the future of novel gastrointestinal procedures. The study [16] intended to demonstrate the viability of RV-NOTES sacrocolpopexy using intraabdominal suturing and knot-tying. The emphasis was on demonstrating straightforward surgical methods for these treatments. The study concludes that the combination of a robotic platform in vNOTES for sacrocolpopexy introduces a novel surgical technique with potential implications for urological procedures.

The study [17] examined the potential effects on sexual function of a surgical procedure that involves removing the kidney from the vagina. The Golombok-Rust Inventory of Sexual Satisfaction (GRISS) questionnaire was used by the authors to assess post-surgical sexual function. The results show comparable overall GRISS scores before and after surgery, indicating no substantial changes in sexual satisfaction. The study concludes that the current landscape of experimental applications of NOTES in gynecological surgery highlights its evolving role and potential advancements. In the study [18], a unique master manipulation with a hybrid parallel/serial architecture was introduced. It has advantages including increased stiffness and precision, a sizable workspace, a low dampening ratio, and simple force feedback implementation. The instrument has three degrees of freedom (DoFs), two rotational forms, and dedicated driving units for each DoF. It has active and passive modes, enabling feedback from forces in all three degrees of freedom. The paper concludes by presenting robot-assisted NOTES, a new master manipulator with force feedback has been developed, showcasing advancements in haptic technology for enhanced surgical control.

The study [19] on vaginal NOTES (vNOTES) experiences and outcomes in gynecologic surgery and focused on the new technique of NOTES. It tries to offer a thorough analysis of the corpus of research that is currently available in the area. The study [20] seeks to demonstrate the step-by-step procedures for effective application of the robotic-assisted high uterosacral ligament suspension. The treatment of prolapsed pelvic organs, either alongside or without uterine preservation, was the main focus. The review concludes that vNOTES finds diverse applications in gynecologic surgery, highlighting its expanding role and potential benefits.

This study looks at the most recent developments in instruments made for NOTES in an effort to close the current gap. Both flexible endoscope prototypes and machine learning robotic platforms are the focus. This study seeks to increase our knowledge of and ability to use NOTES techniques by examining machine learning tools.

Materials and Methods.

The authors of this publication provide research of the most cutting-edge tools currently employed in NOTES. They emphasise how the minimally invasive character of NOTES, which reduces abdominal wall aggressiveness and promises lower postoperative pain, makes it appealing to patients. They do, however, agree that limited access and outdated technology present difficulties for surgeons doing NOTES. To assure the security and repeatability of this novel surgical strategy, the authors stress the need for equipment revision. They cover two major groups of instrumental advancements: flexible devices based on enhanced endoscopic platform and robotic platforms that make use of communications and micromechatronics technologies. In order to create reliable and stable robotic systems for NOTES, the benefits, drawbacks, and possibilities for every category are discussed.

Endoscopic Flexible Platforms

Flexible endoscopes, which typically measure 70 to 180 mm in length and 10mm in diameter are often used instruments in minimally invasive surgery. The "HARP" robot, which is 300mm in length and 12mm diameter, is designed to resemble a snake. It is made up of rigid cylindrical inner and outer snakes joined by spherical joints. By altering the cables, the robot may be either stiff or flexible, much like Shape Lock technology. Early tests on pigs have successfully replaced the inner snake with colonoscope forceps, locked the outside snake, and reached the target. For teleoperated endoluminal surgery, two versions of the ViaCath systems have also been created; the second-generation device has dimensions of 120cm in length and 7.2mm in diameter. It offers nine degrees of freedom and has been tested for mechanical properties. Though, Further testing with phantoms and animal models is necessary.

Figure 2 shows the Transport, a 16mm entry instrument utilized for medical procedures. It has four substantial working channels, including one for a typical 6mm endoscopy and 3 others for large-diameter instruments. Shape Lock is a style used by the Transport device that enables independent guiding of the tip, that may then be secured into place once it's reached the operational site. Stronger and more flexible surgical instruments can pass through the device's big 4mm and 6mm channels. In order to carry out surgical procedures, flexible endoscope platforms for NOTES need to be more strong and stiff. Therapeutic endoscopes used in prototypes are frequently altered by the addition of more channels and larger ones. A 16mm access device with four sizable working channels, the Transport multilumen operating platform was created in association with USGI Medical. Since it makes use of the Shape Lock architecture, the tip can be independently guided before locking into place. Besides three additional channels for large-

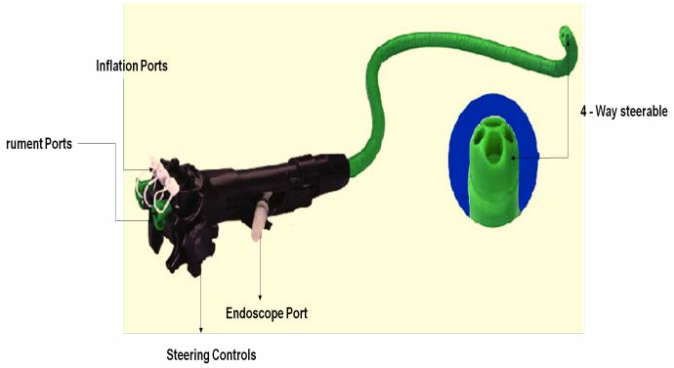

Figure 2. *Shape-lock Transport endoscope.*

diameter instruments, the platform has a normal 6mm endoscope channel. Stronger and more flexible surgical tools can be used thanks to the broad channels, which can produce up to 0.89 kg of force at the tip and 0.1 kg of force when applying pressure.

Growth of the Robotic surgery

Although it is still in the early phases of development, instrumentation for NOTES techniques is essential for the general adoption of NOTES. Robotic technology holds potential for enabling the development of more nimble and precise tools, enabling procedures that are not practical with traditional minimally invasive techniques. Recent years have witnessed the rise of fresh concepts for miniature/modular robots to tackle the drawbacks of conventional medical robots, such as their bulkiness, high cost, constrained field of view, and uncomfortable operation. These machine learning platforms provide prospective remedies for NOTES and laparoscopic surgeries. An overview of the developments in various robotic systems is provided in this section.

Robot Imager

Using an imaging robot during a medical treatment can help by giving visual feedback. The endoscope with a wireless capsule has become a recognized method for inspecting the gastrointestinal tract over the last ten years. The 11 mm by 26 mm capsule that houses the imaging robot also has lighting, imaging, communication modules, and button batteries. After being ingested, the capsule can wirelessly transmit images to an Information from an outside recorder while it passes naturally through the digestive tract via peristalsis. Medical microrobotics have been designed and developed with inspiration from capsules' ingestibility and technological breakthroughs. These capsules, which feature directing or actuating mechanisms, offer a great deal of potential to help with surgical procedures.

This study describes the creation of a camera-equipped robot with a 75mm length and 12mm diameter. Two independently moving wheels on the robot, powered with 6mm DC motors, enable forward, backward, and rotating actions. For the purpose of preventing counterrotation, a tail is used. Between the wheels is a variable-focus image sensor that will provide visual input as the robot moves. The robot was put to the test in a pig modelling test, where it was injected into the abdomen via a transgastric incision, explored the abdominal cavity, and then recovered via the oesophagus using a conventional upper endoscope. Global flexible endoscope market for2021 and 2030 plot is shown in figure 3.

Operative and Cooperative Robot

The dimension of the anatomical orifices restricts the insertion of surgical instruments in minimally invasive procedures like NOTES. One solution to this problem is to employ many microrobots for cooperative activities, with each microrobot in charge of a distinct task. Noninvasive triangulation and retraction can be accomplished inside the abdomen by attaching tweezers and retractors to tiny inside magnets and controlling them with an enormous extracorporeal magnet. This method enables small and straightforward robot structures. Because the gadgets may be easily moved, the system can also be reconfigured.

The MAGS (Magnetic Anchoring and Guidance System) consists of a curvaceously driven arm with a robot with a

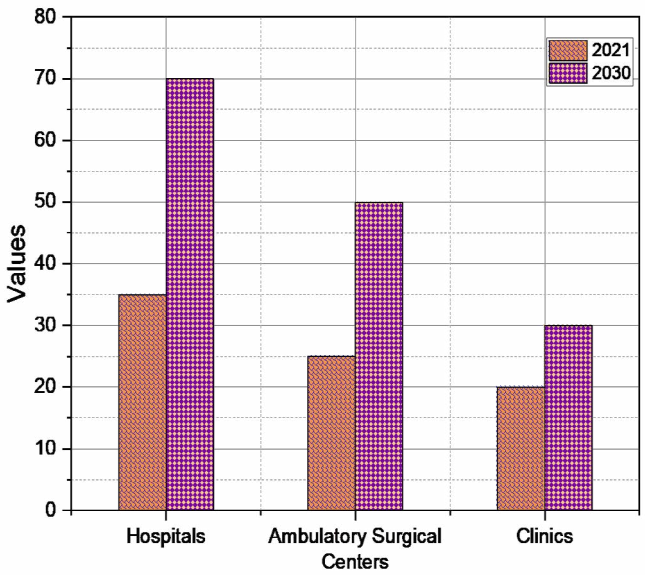

Figure 3. *Global flexible endoscope market for2021 and 2030.*

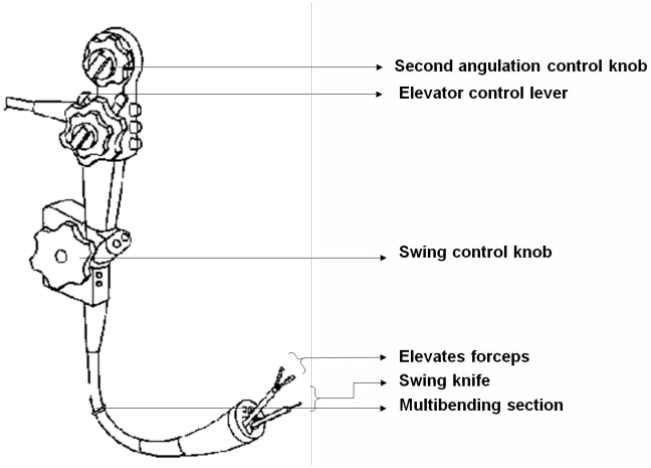

Figure 4. *The R-scope (Olympus Medical Systems).*

cauterising hook, two passive tissue retractors, and an internal camera system. Three degrees of freedom are available on the 158mm-long robotic arm. The first joint has a maximum range of motion of 50 degrees, the second joint a maximum range of motion of 45 degrees. As they have an opportunity to improve the NOTES technique and address issues with flexible platforms, the study's findings promote the further development of magnetic devices for use in humans.

The monocular scope features a multibending portion which allows it to be locked into place while being placed near to the target area. It has two moveable 3.8mm sensor channels, one of which may swing horizontally and the other up and down. As shown in Figure 4, these channels offer a decent simulation of triangulation. During the procedure, both instruments can be controlled via a lever and a knob that are situated close to the R-scope's angulation control knobs. The knob and lever can be locked into the desired positions once they have been chosen for stability.

Self-Building Robot

With the development of Bluetooth programmable robotics for endoluminal treatments, reconfigurable robots originally

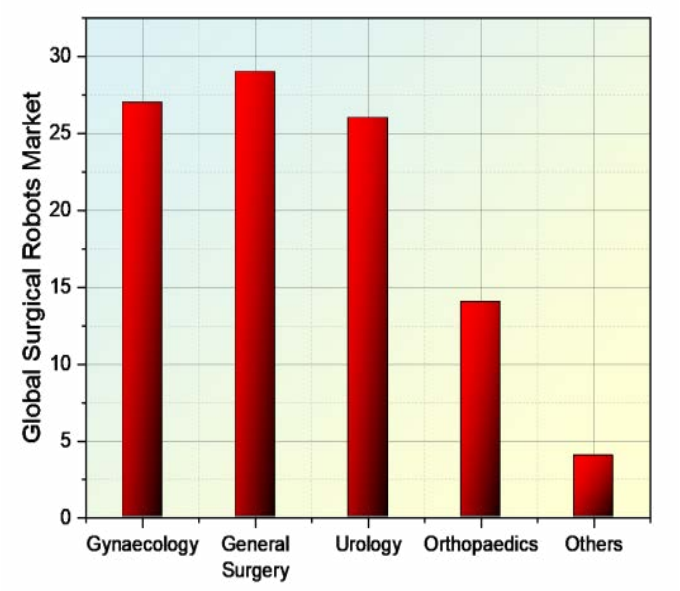

Figure 5. *Global surgical robots market.*

designed for exploration and surveillance have found use in surgery. These robots are assembled, configured, and used surgically under the guidance of a surgeon using an external controller. The centre module, structure modules, and functional modules of modular robots allow for a variety of topologies inside the abdominal cavity. The robots can either keep their shape after the procedure or separate into separate pieces for simple insertion into the body. Self-assembly technology decreases module size and makes it possible to add or remove intervention functions while the procedure is being performed. The disassembly procedure is where the difficulties lay, though. While a magnetic anchoring surface limits some module movements during disassembly, magnetic attraction makes assembly easier. The research offers ideas for future uses despite its limits in 2D operation and 1mm module dimensions, albeit it might not be appropriate for surgical use. Global surgical robots market variation for various categories shown in Figure 5. When compared with the others, general surgery in robotics were higher.

Limitations.

Robotic technique offers various benefits for surgical procedures like NOTES when compared to flexible endoscopes. It offers a solid and secure platform, enhances geometry and ergonomics, and permits the use of several surgical instruments. Individual functioning robots' structures can be made simpler and can be made smaller to fit via a single port thanks to the flexible and cooperative architecture. Microrobots are effective at helping with additional work support and visualization, according to experimental assessments. But at the moment, in vivo robots are still being tested in non-survival animals and are not yet developed enough for clinical application. Although this strategy has promise, more technology advancement is required to overcome present restrictions and guarantee simplicity of use and security in the long run.

In the framework of NOTES, robot technology has a number of drawbacks. Widespread acceptance is hampered by the intricacy of the procedure and the steep learning curve required of the surgeons, as well as by the high initial price and continuing maintenance expenditures. Limited haptic feedback makes it difficult to remote control capabilities, and measure tissue raise latency issues. Robotic system manoeuvrability and efficiency in confined environments are impacted by their size and configuration. Challenges include a shortage of sensory perception, vulnerability to technical issues, and incompatibility with specific processes. The lack of complete tactile feedback and restricted access to anatomical regions, along with other legal, moral, and integration difficulties, further limit their application. To fully utilize the capabilities of robotic platforms in NOTES, it was essential to address these constraints through research and development.

Conclusions.

The NOTES has the capacity to bring about yet another significant paradigm shift in surgery, comparable to the influence of laparoscopic operations during the past three decades. Clinical and engineering restrictions need to be resolved before widespread usage, though. Creation of new operating platforms with a focus on NOTES is a crucial demand. However, these have limits in terms of transvaginal procedures, rigidity, and meeting the needs of geometry and retraction. Recent studies have used modified flexible endoscopes or standard laparoscopic instruments. The creation of novel instruments, notably in the realm of robotics, offers hope for overcoming these constraints. Pilot experiments have shown that using operating and image microrobots for task support is feasible. It is necessary to conduct more research, including assessments of animal survival models and, eventually, assessments of both safety and effectiveness in humans. Future NOTES techniques are projected to develop and gain widespread acceptance because to developments in robotics.

REFERENCES

1. Lerner VT, May G, Iglesia CB. Vaginal Natural Orifice Transluminal Endoscopic Surgery Revolution: The Next Frontier in Gynecologic Minimally Invasive Surgery. JSLS: Journal of the Society of Laparoscopic & Robotic Surgeons. 2023;27.

2. Wang CJ, Go J, Huang HY, et al. Learning curve analysis of transvaginal natural orifice transluminal endoscopic hysterectomy. BMC surgery. 2019;19:1-7.

3. Baekelandt JF. New retroperitoneal transvaginal natural orifice transluminal endoscopic surgery approach to sentinel node for endometrial cancer: a demonstration video. Journal of Minimally Invasive Gynecology. 2019;26:1231-1232.

4. Lei Y, Li Y, Song R, et al. Development of a novel deployable arm for natural orifice transluminal endoscopic surgery. The International Journal of Medical Robotics and Computer Assisted Surgery. 2021;17:e2232.

5. Ullah S, Ali F.S, Liu B.R. Advancing flexible endoscopy to natural orifice transluminal endoscopic surgery. Current Opinion in Gastroenterology. 2021;37:470-477.

6. Lowenstein L, Matanes E, Weiner Z, et al. Robotic transvaginal natural orifice transluminal endoscopic surgery for bilateral salpingo oophorectomy. European journal of obstetrics & gynecology and reproductive biology. 2020;10:100113.

7. Koythong T, Thigpen B, Sunkara S, et al. Surgical outcomes of hysterectomy via robot-assisted versus traditional transvaginal natural orifice transluminal endoscopic surgery. Journal of minimally invasive gynecology. 2021;28:2028-2035.
8. Lowenstein L, Mor O, Matanes E, et al. Robotic vaginal natural orifice transluminal endoscopic hysterectomy for benign indications. Journal of Minimally Invasive Gynecology. 2021;28:1101-1106.
9. Cheng T, Zhang G, Sun J, et al. Dexterity enhancement of continuum robot for natural orifice transluminal endoscopic surgery in the dual-manipulator collaborative space. The International Journal of Medical Robotics and Computer Assisted Surgery. 2023:e2516.
10. Isono W, Tsuchiya H, Tsuchiya A, et al. Obvious advantage of vaginal natural orifice transluminal endoscopic surgery hysterectomy against total laparoscopic hysterectomy in small uterus patients and the future prospects at a regional core institution: A retrospective study. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2023;10:100206.
11. Yang Y.S. Robotic natural orifice transluminal endoscopic surgery (NOTES) hysterectomy as a scarless and gasless surgery. Surgical endoscopy. 2020;34:492-500.
12. Koythong T, Thigpen B.A, Sunkara S, et al. Surgical Outcomes of Hysterectomy Via Robotic Assisted Versus Traditional Transvaginal Natural Orifice Transluminal Endoscopic Surgery. Journal of Minimally Invasive Gynecology. 2021;28:S51.
13. Chan K.L, Yeung C.K, Lam K.W, et al. Robotic Natural Orifice Transluminal Endoscopic Surgery Hysterectomy and Salpingo-Oophorectomy in a Porcine Model. Surgical Innovation. 2022;29:215-224.
14. Guan X, Welch J.R, Wu G. Robotic transvaginal natural orifice transluminal endoscopic surgery for resection of parametrial and bowel deeply infiltrated endometriosis. Journal of Minimally Invasive Gynecology. 2022;29:341-342.
15. Simsek C, Kaan H.L, Aihara H. Future Directions for Robotic Endoscopy–Artificial Intelligence (AI), Three-Dimensional (3D) Imaging, and Natural Orifice Transluminal Endoscopic Surgery. Techniques and innovations in gastrointestinal endoscopy. 2023;25:95-101.
16. Guan X, Guan Z, Koythong T, et al. Integration of a robotic platform for sacrocolpopexy in transvaginal natural orifice transluminal endoscopic surgery: a novel surgical technique. Urology. 2021;154:109-114.
17. Barra F, Alessandri F, Evangelisti G, et al. Natural Orifice Transluminal Endoscopic Surgery (NOTES): Landscape of Current Experimental Applications in Gynecological Surgery. Journal of Investigative Surgery. 2021;34:922-923.
18. Wang C, Zhao J, Wang S, et al. A Novel Master Manipulator with Force Feedback for Robot-Assisted Natural Orifice Transluminal Endoscopic Surgery. In 2019 IEEE International Conference on Mechatronics and Automation (ICMA). 2019:1282-1287.
19. Reddy H, Kim S.W, Plewniak K. Applications of vaginal natural orifice transluminal endoscopic surgery (vNOTES) in gynecologic surgery. Current Opinion in Obstetrics and Gynecology. 2022;34:220-226.
20. Liu J, Guan Z, Tang L, et al. Robotic assisted vaginal natural orifice transluminal endoscopic surgery high uterosacral ligament suspension (NOTES-HUS) for uterine prolapse with and without uterine preservation. Intelligent Surgery. 2022;3:14-15.