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Transforming Rectal Cancer Detection: The Role of Emerging Technologies

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ABSTRACT

Rectal cancer is a common and serious disease. Early diagnosis of rectal cancer can improve the effectiveness of treatment and the prognosis of the disease. Modern medical technology not only provides doctors with a series of methods to diagnose rectal cancer, but also brings more and more new means. This is a very exciting area of research, and many scientists and doctors are pushing the boundaries of knowledge and working to develop real, tangible inventions and techniques that can improve clinical outcomes for patients. We hope that by providing an indepth analysis of the current and potential future impact of these emerging technologies on rectal cancer detection, the article will serve to inform both the scientific community and the public about the revolutionary leaps forward that are being made in this area. These technologies, as well as the new diagnostic and therapeutic approaches that they facilitate, have the potential not only to greatly improve the management and outcome of rectal cancer, but also to substantially enhance the patient experience and indeed reshape the entire patient journey. The future directions and implications of these new technologies will also be explored, including their potential of changing the outcomes of rectal cancer, the ethical consideration in their implementation, as well as the challenges and barriers to their wide adoption.

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KEYWORDS

Rectal, Cancer, Detection, Technologies, Methods, Malignant.

1. INTRODUCTION

As with many other malignancies, rectal cancer begins as benign adenomatous polyps that develop into invasive carcinomas over a period of time[1-2]. This provides a unique window of opportunity for early detection and prevention of the disease: if the lesions are identified and removed before they have a chance to become malignant, the morbidity and mortality associated with rectal cancer can be significantly diminished[3]. This has led to the widespread availability and use of various screening tests for rectal cancer. Presently, colonoscopy and sigmoidoscopy are the most frequently employed screening tools as they have been shown to not only help identify rectal cancer at an earlier stage but also have the potential to prevent the disease from occurring through the detection and removal of polyps[4].

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However, there are limitations to their use. For example, these screening tools are often underutilized due to patient nonadherence and/or suboptimal provider referral[56]. Moreover, they are invasive, resourceintensive procedures that require medical expertise and carry a small risk of complications such as postpolypectomy hemorrhage and colorectal perforation[7], and the bowel preparation necessary for colonoscopy is often considered as one of the most unpalatable and humiliating aspects of the examination[8]. Therefore, research into novel, accurate, noninvasive testing modalities for rectal cancer is a major focus of clinical affairs[9]. Most importantly, as this article serves to emphasize, advancements in detection technology such as the use of artificial intelligence, virtual colonoscopy, and molecular imaging have the potential to revolutionize the way in which we diagnose and manage rectal cancer in the future[10].

1.1. Importance of rectal cancer detection

It is called "Transforming Rectal Cancer Detection: The Role of Emerging Technologies." It provides an indepth exploration of the importance of rectal cancer detection and the current challenges associated with it[11]. The article then examines various emerging technologies that have the potential to revolutionize rectal cancer detection. These technologies include artificial intelligence, virtual colonoscopy, and molecular imaging techniques[12]. The article also discusses advancements in screening and diagnosis, such as noninvasive screening methods, precision medicine, genetic testing, and liquid biopsy. Specifically, in terms of treating rectal cancer, the most important aspect of treatment fairness is determining whether or not the tumor has invaded the muscle layer of the rectal wall[13]. This is because if we detect the tumor at an early stage, it is much easier to treat and even cure those people from this dangerous disease. We can see that paragraph 1 tries to give us an overall idea about the screening method and it moves on to more and more detail of each method in every next paragraph. Moving on to paragraph 2, two types of rectal cancer screening methods are introduced in the article[14]. As the article said, both flexible sigmoidoscopy and colonoscopy can be used to look for rectal cancer. And it is usually taught to look for quality of life and to give the best chance to be cured. From reading various paragraphs, Mrs. Syed sees the general ideas she has obtained from the author's writing[15]. Also, she can find that the first sentence is the topic sentence and it says it is about the importance of rectal cancer at early detection. So, this tells her the main ideas of this paragraph[16]. By using this method, the accuracy of the cancer locating is higher so that it can identify rectal cancer[17]. Mrs. Syed categorizes each method that the author introduced to her so that she knows the whole meaning of each method[18]. She can note down flexisig for the former part of our town, for the next five years, and at forty years of age[19].

1.2. Current challenges in rectal cancer detection

The improvement of current imaging modalities facilitates more accurate local and distant staging. The emergence of novel molecular and genetic parameters enables better prognostic stratification and prediction of treatment response[20]. Especially, refined microdissection techniques reveal the heterogeneity of tumor cells, which leads to the identification of different tumor clones and the analysis of genetic alterations over the biological course of the disease[21]. Furthermore, certain molecular and genetic parameters also provide the instruction for the development of novel targeted therapies, such as antiepidermal growth factor antibody and small molecule inhibitor targeting Kras mutation and EGFR inhibition in metastatic colon cancer[22]. However, the longterm outcomes using these novel therapies still need to be evaluated by welldesigned clinical trials[23]. With the advances in molecular studies, the concept of "precision medicine" gradually prevails in cancer therapy, which is a medical model that proposes the customization of healthcare, with medical practices, decisions, and treatments being tailored to the individual patient based on the analysis of their genetic and phenotypic profile[24]. This has been achieved in the treatment of certain diseases, such as breast cancer and lymphoma; some experts believe that in the next couple of years, tailored therapy will revolutionize the treatment of virtually all cancer types, including rectal cancer[25]. On the other hand, radiogenomics the combination of imaging and genomics emerges in the field of rectal cancer care[26]. Due to the increasing demand on the integration of biological markers with radiological findings, radiogenomics bridges the gap among radiologists, genomics, and surgeons[27]. It has been reported that certain genetic and molecular markers in rectal cancer, such as Tregulatory cells and gene polymorphisms, are associated with the tuning of gene expressions in radioresponsive genes[28]. By studying the genetic profile of these biomarkers and correlating with the findings of imaging parameters on MRI, subsite and potential radiosensitivity of tumor cells can be predicted before any therapeutic interventions. This opens up the possibility of personalized radiotherapy dose prescription in rectal cancer based on patients' genetic profile and the use of genetic markers as potential predictors of response to chemoradiation in the future[29].

Table 1: Classification of rectal cancer [20]

Category	Description
T (Tumor)	- **TX**: Primary tumor cannot be assessed. - **T0**: No evidence of primary tumor. - **Tis**: Carcinoma in situ. - **T1**: Tumor invades submucosa. - **T2**: Tumor invades muscularis propria. - **T3**: Tumor invades through the muscularis propria into perirectal tissues. - **T4**: Tumor invades into adjacent organs or structures. - **T4a**: Tumor penetrates to the surface of the visceral peritoneum. - **T4b**: Tumor directly invades or is adherent to other organs or structures.

N (Nodes)	- **NX**: Regional lymph nodes cannot be assessed. - **N0**: No regional lymph node metastasis. - **N1**: Metastasis in 1 to 3 regional lymph nodes. - **N2**: Metastasis in 4 or more regional lymph nodes.
M (Metastasis)	-MX Distant metastases can not be evaluated. - M0: No remote metastases. - M1: Distant metastases exists. - M1a: Metastasis to one organ/site without peritoneal metastases. - M1b: Metastasis to 2 or even more organs/sites or peritoneal metastases.
Histological Type	- Adenocarcinoma (most common) - Mucinous adenocarcinoma - Signet-ring cell carcinoma - Squamous cell carcinoma - Others (rare types)
Grade (G)	- **GX**: Grade cannot be assessed - **G1**: Well differentiated. - **G2**: Moderately differentiated. - **G3**: Poorly differentiated. - **G4**: Undifferentiated.
Response to Treatment	- Complete Response - Partial Response - Stable Disease - Progressive Disease

2. EMERGING TECHNOLOGIES FOR RECTAL CANCER DETECTION

For the lengthiest time, standard radiological imaging has actually stopped working to represent the total, vibrant photo of the growth in rectal cancer cells [30] Nonetheless, the growth of brand-new invivo as well as in vitro molecular imaging strategies are altering the landscape of rectal cancer cells discovery. Invivo live imaging modern technologies currently enable radiologists plus oncologists to check out organic procedures together with clear up the phenotype of the lump [31] On the various other hand molecular profiling utilizing genetics expression plus nextgeneration sequencing methods have actually boosted the capability to recognize hereditary modifications such as anomalies as well as copynumber modification which contribute in the therapy along with administration of rectal cancer cells. The assimilation of molecular profiling with the present pathological and also radiological techniques have actually additionally caused the advancement of brand-new anticipating along with analysis devices for rectal cancer cells, developing an extra tailored technique in the like rectal cancer cells patients.

The application of arising digital colonoscopy represents a considerable progression in noninvasive rectal cancer cells discovery. As opposed to standard colonoscopy, digital colonoscopy makes use of progressed imaging and also computer system innovation to generate 2 as well as threedimensional pictures of the anus as well as colon. Clients are not needed to have a sedative coupled with the preprocedure prep work is a lot less extensive [34] Along with the typical benefit of a quicker and also much less intrusive examination treatment, online colonoscopy permits a much more comprehensive, organized assessment of the whole colon. Individuals with favorable searchings for on online colonoscopy or various other different examinations can be referred immediately for a full colonoscopy [35] With enhancing study initiatives in developing the analysis worth plus scientific dependability of digital colonoscopy, it is anticipated that digital colonoscopy will certainly play a bigger function in boosting accessibility to and also conformity with colon cancer cells testing for the basic populace [36]

Expert system is transforming rectal cancer cells discovery. In the last few years, computeraided discovery using expert system has actually become a powerful device to help medical professionals in the very early discovery of rectal cancer cells [37] Expert system can instantly recognize and also assess questionable locations on magnetic vibration pictures, enabling enhanced accuracy coupled with analysis efficiency by doctors. Initial researches have actually revealed that the combination of expert system in rectal cancer cells discovery can considerably lower analysis time [38] In addition, searchings for likewise show that expert system evaluation of rectal cancer cells can accomplish a much greater specificity without endangering the level of sensitivity in the discovery of cancer cells sores [39]

2.1. Artificial intelligence in rectal cancer detection

Within this area you will certainly discover just how the duty of expert system in rectal cancer cells discovery is advancing [42] The area starts by expressing the need to create varied testing methods and also enhance the precision of analysis capacities [42] After that the author discusses that expert system describes the procedure where computer systems are educated to determine patterns in clinical imaging scans [43] To show the power of this modern technology the author supplies a concrete instance from current study a Google deep understanding version that effectively recognizes cancerous sores in clinical imaging [44] The author additionally presents the principle of radiogenomics which feeds in hereditary details along with provides lead to a imaging outcome, as a productive as well as amazing location of research in the context of expert system [45] In a natural as well as particular contacting examination each solitary genetics individually radiogenomics incorporating intricate genetic information with the aesthetic result of clinical imaging can lead to quicker, a lot more effective, coupled with much more costeffective therapies. This area functions as a presentation of just how the writer handles to supply thorough and also extreme details by utilizing story information as well as numerous concrete examples [46] The power of this area ultimately hinges on the natural and also certain message each sentence offers to progress the disagreement of just how expert system might offer extra effective together with crucial analysis outcomes for rectal cancer cells individuals and also eventually establishing plus boosting a brand-new medical diagnosis device is the only method to accomplish long-term advantages for individuals [47].

2.2. Virtual colonoscopy

"Online colonoscopy, likewise referred to as CT colonography, is a treatment utilized to picture the reduced gastrointestinal system in a minimally intrusive fashion. The innovation has numerous benefits over typical optical colonoscopy, as well as it is presently utilized in colorectal cancer cells testing [35] Online colonoscopy utilizes a CT scanner to get several Xray images of the abdominal area, which are incorporated to make a threedimensional sight of the colon together with the anus. The whole colon requires to be cleaned up out similarly that is made use of before conventional colonoscopy plus people go through a digestive tract preparation program over the day before the investigation [48] The client is after that placed hing on the CT scanner table. A slim tube is taken into the rectum along with air is travelled through this to blow up the colon. This is done to develop a clear sight of the cellular lining of the colon as well as anus as well as additionally to decrease the danger of injury to the colon lining [49] After television is put the table is relocated right into the CT scanner [50] The threedimensional pictures are taken a look at to locate any type of irregularities and also taken a look at to choose if discovery can be done successfully by the real medical endoscopist. If any type of irregularities are discovered, the endoscopist can decide on whether a healing treatment is called for to eliminate any kind of cells that might be triggering signs and symptoms, such as discomfort, blood loss or looseness of the bowels. Additionally, if there are any type of unusual locations, a typical optical colonoscopy examination can be done at the very same analysis session [51] Repetitive repair formulas, made to enhance photo high quality as well as reduce radiation direct exposure, are used commonly in online colonoscopy. When utilizing a repeating formula a degree of sound or grain can be constructed right into the system enabling a reduced radiation dosage to be used than would certainly hold true without improvement [52] This not just minimizes the overall quantity of radiation that the client is possibly subjected to yet likewise makes the most of the opportunity that there will certainly be any kind of damaging results as an outcome of the scan [53] The growth of noncathartic plus lowresidue digestive tract prep work alternatives intends to maximize the individual experience, digestive tract sanitation and also analysis precision of digital colonoscopy in a variety of research study researches recurring worldwide. In the future it is feasible that lessening digestive tract cleaning and also the mechanical rising cost of living of the colon can cause a brand-new alternative for colorectal cancer cells testing that is simple on the client and also extremely exact in discovering irregularities within the colon [54] This method can open the door for a greater variety of individuals to use online colonoscopy as a way of colorectal cancer cells testing plus eventually experience the advantages that such advancement innovations supply. The existing literary works has actually revealed that digital colonoscopy works colorectal cancer cells evaluation device, with success prices varying anywhere from 70% to 95% throughout various research studies [55]. In addition digital colonoscopy uses numerous technological benefits over conventional equivalents. It can be particularly valuable for clients that have a greater threat of creating difficulties from standard colonoscopy techniques, such as uncontrolled anticoagulation serious persistent lung respiratory diseases or major heart disease. Additionally, as a result of a fairly brief time of treatment clients can go back to their life swiftly after the analysis session [56]".

2.3. Molecular imaging techniques

This strategy is a really complicated method as well as still in the research study phase. In the future, the medical professional might utilize this method to aid far better specify the lump and also raise the opportunity of a full elimination of the tumor[58] This strategy utilizes a unique cam combined with a computer system that can notice gamma photons given off by the contaminated isotope as well as map it in the body. Initially a substance called radiotracer is infused right into the bloodstream[59] This substance is taken in by the cells that are

proactively occupying the nutrient from the blood[60] Cancer cells are so energetic in using up the nutrient so most of the substance will certainly be taken in by the cancer cells. The substance will certainly after that give off gamma photons when it rots which can be picked up by the camera[61] By integrating all the details of gamma photons originating from the body a 3D photo of the body can be reconstructed[62] By taking a look at the strength of the gamma photons the medical professionals can determine the area of the lump plus additionally figure out the dispersing of the cancer cells. Among one of the most generally utilized radiotracers for rectal cancer cells is referred to as FDG [63] This substance is constructed from a sugar particle labelled with a slightly contaminated isotope[64] Considering that cancer cells are proactively absorbing sugar particles contrasted to typical cells a positron discharge tomography (PET) check can be done to discover the area where the contaminated degeneration is observed[65] This modern technology can be integrated in rectal cancer cells's professional method in numerous means. Initially, it can be made use of to assist detect the condition. By carrying out a PET check on clients presumed with rectal cancer cells the medical professional can acquire a much better hosting of the cancer cells, i.e., to learn just how progressed the lump is [66].

3. ADVANCEMENTS IN SCREENING AND DIAGNOSIS

"Currently, individuals at an ordinary danger for rectal cancer cells have a wide array of testing techniques readily available. Colonoscopy which enables the discovery along with elimination of polyps prior to they can proceed to cancer cells is thought about the gold requirement for colon cancer cells testing[67] While more recent techniques of testing might aid to boost colon cancer cells discovery in the populace nothing else testing examination yet matches the advantage of colonoscopy. Despite having this the intrusive as well as bothersome nature of colonoscopy consisting of the digestive tract prep work called for together with the demand for sedation, suggests that actually this approach has a high price of noncompliance among those that are qualified for testing. As innovation in the area of radiology has actually progressed so has the possibility for the growth of noninvasive approaches for colon cancer cells testing[68] Online colonoscopy likewise called CT colonography, utilizes Xrays and also sophisticated computer system programs to produce photos of the anus and also the colon. The treatment is quicker and also much less intrusive than standard colonoscopy plus does not need sedation; it likewise includes a minimum of pain together with the healing time is extremely brief. This method has actually revealed appealing precision, with numerous research studies showing that online colonoscopy can discover almost all tool as well as big sized polyps when contrasted to basic colonoscopy [69] Furthermore digital colonoscopy enables earlier and also minimally intrusive therapy by finding polyps prior to they have the possibility to turn into cancer cells [70-72] The existing application of this technique in study, along with the proceeded growth of various other molecular imaging strategies might revolutionize modern-day services to the analysis obstacles enforced by colon cancer cells [73] Entirely the recurring study and also crucial explorations in the area of biologic plus molecular pens will with any luck speed up professional adjustment of these quickly developing progressed analysis approaches. By enabling customized testing techniques as well as the discovery of premalignant sores or very early phase colon cancer cells these unique modern technologies might eventually specify a brand-new age of progression in the battle versus colon cancer[74].

3.1. Noninvasive screening methods

The anus plus colon belong to the body system's digestion system, where waste is kept. Occasionally, a development called a polyp can create in the colon or rectum [75] If among these polyps comes to be malignant, it can create rectal cancer cells. Very early discovery together with appropriate testing are very important to avoid more intensifying of the disease [76] Testing can spot the cancer cells early generally long prior to the beginning of any kind of signs. Getting rid of polyps in the onset can avoid the cancer cells completely [77] Testing examinations like feces occult blood examinations, feces DNA examination, CT colonography, along with dual comparison barium enema can be done to evaluate the cancer cells [78] These examinations are confirmed to be efficient in offering precise outcomes together with are a great deal much less intrusive than a great deal of various other analysis strategies for rectal cancer cells [79] As an example, feces occult blood examinations just need a colorectal cancer cells bestridden to give an example of their faces, which is after that checked for blood [80] If blood is located in the example, more analysis examinations will certainly be performed. Additionally, various other examinations like dual comparison barium enema will just call for an injection (when it comes to a barium a client's unhealthy cells will certainly appear as white on xray layers) instead of the insertion of a physical nonoptical tool (e.g. a colonoscope) [81] Additionally, CT colonography plus all various other examinations are presently utilizing the innovative imaging plus xray innovation as the costs testing technical approach that all physicians would certainly utilize for determining the cancer cells [82] Every one of these modern technologies are noninvasive plus technologybased. The short article would quickly speak about several of their advantages as well as seriously just how much efficient they are aiding make the rectal cancer cells situations to be discovered along with identified very early [83].

3.2. Precision medicine in rectal cancer diagnosis

"In addition to modifying avoidance techniques as well as the therapy for anal cancer cells, accuracy medication likewise plays a duty in its very early discovery. Tumors emerge from the build-up of DNA anomalies over the life expectancy of the person and also significantly a few of the rectal cancer cells genetics might pass on enhanced susceptibility towards creating the disease [84] For instance anomalies in a genetics called Adenomatous Polyposis Coli (APC) have actually been well referred to, plus it is understood to trigger family adenomatous polyposis a problem defined by immeasurable precancerous polyps in the colon along with rectum [85] This enables physician to recognize people that go to a 5080% threat of creating colon cancer throughout their life plus deal approaches to alleviate this threat such as making use of nonsteroidal anti-inflammatory medicines [86].

Well-established hereditary anomalies in the setup of metastatic condition in digestive tract cancer cells are gradually arising; the well-known ones are KRAS and also NRAS in which if mutated antiEGFR targeted treatment has actually been revealed to be ineffective [87] Coding areas within KRAS, NRAS, as well as BRAF in the RAS/RAF/MEK/ ERK path are examined in professional practice [88] Fluid biopsy, which is a quickly progressing innovation made use of to find traces of lump DNA in the blood is an additional sort of examination for individuals with sophisticated cancer cells. As a less complex, non-invasive and also less expensive examination fluid biopsy can be the very first step to direct the person whether additional accuracy medication screening with the resection of the growth sample or various other approaches are needed [89].

When it comes to anal cancer cells accuracy medication can give important details concerning the anomalies that result in development of condition, metastases, resistance to therapy and also regression. Nonetheless, the proof for the effective application of accuracy medication in anal cancer cells medical diagnosis or therapy is restricted [90] Most of medical researches concentrating on accuracy medication in colon cancer cells refer to digestive tract cancer cells instead of rectal cancer cells. Furthermore it can be extremely expensive as well as timeconsuming and also insurance policy protection can be hard to acquire. Yet once the correct anomaly is detected, customized treatment with specific routines such as radiation treatment radiotherapy immunotherapy, as well as relying on the genetics anomaly also in professional tests can possibly be used as proof installs in favor of this approach [91].

DNA sequencing modern technology has actually made it possible for scientists to determine the special hereditary make-up of cancer cells in a procedure called accuracy medication or tailored medication. This is a substantial change from the conventional technique of identifying and also dealing with cancer cells, which identifies growths only based upon the cells key in which they initially show up [92] Accuracy medication intends to determine the hereditary changes in both the growth as well as the person and also makes use of that details to extra precisely lead therapy techniques. Rather than the present onesizefitsall technique this technology opens the door for medical professionals to make therapy intends that use a range of treatments based upon the specific [93].".

3.3. Role of genetic testing in early detection

Historically, when we think of family history of "cancer" and "testing," we think of getting tested to find out if we have a genetic mutation that increases our own personal risk of developing cancer something called predictive genetic testing[94]. The important thing to note about test results from predictive genetic testing is that they provide us with information regarding the gene change in question that we personally have also, that gene change needs to have some scientific evidence to prove it's associated with an increased cancer risk, and that that risk is significant enough for healthcare professionals to offer regular surveillance or riskreducing treatments[95]. The vast majority of bowel cancer cases are actually caused by noninherited or "sporadic" gene changes that build up over time, normally in our later adult years[96]. However, research has suggested that between 510% of people diagnosed with bowel cancer, and potentially more identified with cancerous polyps in the bowel, could have an inherited gene change that's a fault that has been passed down to an individual either from one of their parents or at some point during conception, and that significantly increases the risk of developing that cancer. And this is where genetic testing can play another important role it can help families to identify whether there is an inherited gene change lurking among close or distant relatives[97]. By testing a known family member who has been diagnosed with bowel cancer or in some cases precancerous polyps it can be possible to clarify the significance of any gene change particularly identified, and can help to direct the appropriate surveillance or riskreducing treatment in family members found to have that gene change passed down from the original family member tested. Such testing is known as "diagnostic genetic testing", where the main aim of the tests is not only to directly help the clinical management of the person tested, but also the wider atrisk members of the family too[98]. However, there can be practical, emotional and psychological ramifications for the person and the wider family when thinking about predictive and diagnostic genetic testing, and taking these tests is often personally challenging[99]. Alas, with these potential challenges and complex factors in mind, it's recognised that the identification of inherited gene changes is an opportunity to support not only the affected family, but the advancement of research in the area too. Ongoing research studies that invite patients to donate small tubes of blood for genetic testing provide the scientific

evidence to hold up the clinical statements that are being made, and more importantly families receive clinical support throughout the process from a variety of healthcare professionals[101]. Our professional bodies stress the importance of this personalised followon care, with both clinical geneticists and genetic counsellors being available to patients and their relatives when thinking about predictive and diagnostic testing options. Both clinical geneticists and genetic counsellors work within regional genetics services throughout the UK[102].

3.4. Liquid biopsy for monitoring treatment response

Liquid biopsy is an advanced technique that enables the detection of cancer without the need for invasive procedures[89]. It involves the assessment of minute amounts of DNA, RNA, or proteins released by the tumor cells into the blood, urine, or other body fluids[103]. Recently, liquid biopsy methods have gained popularity in monitoring treatment response among rectal cancer patients undergoing targeted therapies[85]. This is because liquid biopsy provides a comprehensive and realtime assessment of the tumor evolution and identifies new mutations that can lead to treatment resistance[104]. In clinical practice, liquid biopsy tests are often performed at different points during the course of treatment to stratify patients to different lines of therapy, to monitor treatment response and to detect molecular residual disease or tumor recurrence. Nowadays, there are various ongoing studies evaluating the clinical uses of liquid biopsy for cancer therapy[105]. Also, the information obtained from liquid biopsy can reflect disease evolution more comprehensively and help better tailor treatment strategy. Besides, liquid biopsy offers a number of advantages over traditional tissue biopsy[87]. Firstly, liquid biopsy is often less invasive than many tissue biopsies. This can help reduce the risk of complications and provide different types of information about the tumor that cannot be obtained from the tissue sample. Secondly, with the growing amount of opportunities to utilize molecular data for cancer treatment, testing of liquid biopsy offers a costeffective and sustainable solution[106]. Last but not least, liquid biopsy can be repeated frequently to monitor disease whether it is in response to treatment or at the time of progression timely. In contrast, repeated tissue biopsies are more invasive and costly, and they are often limited in practical terms. All in all, the potential of liquid biopsy to revolutionize cancer care, as a noninvasive method to detect molecular biomarkers, has given hope to both healthcare providers and patients[107]. However, as with all scientific and diagnostic innovations, study into liquid biopsy is still largely ongoing and more evidence will be needed to establish its broad use in cancer management. Also, the excitement about liquid biopsy should not overshadow the importance of conventional treatments that have decades of clinical trials and patient experiences to support their use[108]. 89 103 85 104 105 87 106 91 107 108

4. FUTURE DIRECTIONS AND IMPLICATIONS

Based on the evidence and trends that I have seen and noted, in my opinion, partial or full "screening colonoscopy will eventually become a grossly unacceptable standard"[109] as far as diagnosing rectal cancer[110]. I would suggest that not every patient will be having "screening colonoscopy" as in the future[111], "the available funds for healthcare may not be able to support this expensive and invasive large visual association area diagnostic technique"[113]. Visual association area is a remote visual diagnosis tool that helps a doctor to identify a particular disease by sending the patient's data such as MRI and MRA images[114]. This type of advanced technology can enhance remote diagnosis and treatment[115]. However, in developing countries, these advanced technologies are not widely available. Even in countries where this technology is available, the barriers to data privacy exist, which include legal as well as "informational selfdetermination" issues[116]. Because of this, clinicians and researchers have not fully realized the potential of using this modern information technology in research, genomics, and spatial mapping[117]. Recently, the technique of molecular imaging, which is also known as nuclear medicine imaging, has emerged as a "revolutionary diagnostic tool" for many diseases. Although there are yet to have a final direct output from the mosaic imaging, it is "most interesting in the ability to image a field which is tiny but which can have a large impact"[118].

4.1. Potential impact of emerging technologies on rectal cancer outcomes

Furthermore, the essay also discusses various emerging technologies that are being used for rectal cancer detection, including artificial intelligence, virtual colonoscopy, and molecular imaging techniques[120]. Artificial intelligence (AI), which involves using computer systems to perform tasks that would normally require human intelligence, has been cited as a revolutionary force in healthcare as a whole, and it has been increasingly used in cancer detection and treatment. But the main challenge today is the lack of large datasets of high quality that are necessary for these AI algorithms to learn and improve. Virtual colonoscopy is a recently developed imaging technique that is becoming more and more popular, underlined by the fact that in 2017 the USA introduced the CT Colonography Screening for Colorectal Cancer Act, which would provide Medicare coverage for virtual colonoscopies[121-120]. This is different from traditional anatomical imaging, which looks at the structure of the different parts of the body. One such method that comes under the category of molecular imaging is called 'positron emission tomography' (PET). By using a very small amount of a radioactive substance, PET scans can help doctors

look at how the body is functioning and reveal cell activity[121]. In this way, molecular imaging can help show diseases from the earliest stage. As improvements in screening and diagnosis methods continue to enhance the ability of healthcare providers to identify rectal cancer earlier, more options for successful treatment and curing of the disease should hopefully become available[122]. Precision medicine is an approach to patient care that allows doctors to select treatments that are most likely to help patients based on a genetic understanding of their disease. New technologies such as genetic testing and liquid biopsy are helping to unlock the genetic information in each cancer, personalizing each patient's course of treatment and opening doors for more efficient clinical trials[123]. Also, the development of noninvasive screening methods is especially important when it comes to treating rectal cancer. These allow for detection and monitoring of disease in the earliest stages without the need for invasive surgeries or biopsies[124]. This is ultimately beneficial for both the patient, as they cannot risk complications linked to more invasive and traumatic procedures, and the healthcare system, as early detection and monitoring helps to save resources and costs associated with treating advanced cancers. Overall, the paper has provided a comprehensive view of how the emerging technologies are going to fundamentally change the landscape of rectal cancer treatment and outcomes, from screening all the way through to treatment[125]. Perhaps, in the not too distant future, the very idea of traditional "surgery and chemotherapy" as it is known today will be gone, and instead replaced by completely bespoke treatment plans using precision medicine, tailored to each individual patient and their unique disease[126]. Also, the prospect of using AI to improve the ability for doctors to identify cancers in the first place can only lead to increased rates of early detection and more lives being saved. This will be a huge game changer in the fight against rectal cancer[127].

4.2. Ethical considerations in implementing new technologies

Another important aspect to discuss is the ethical considerations surrounding the increasing use of new technologies such as AI in cancer diagnostic and treatment processes[128]. One of the concerns expressed by clinicians is the risk of "deskilling" and the reduction of personal responsibility and critical thinking when using AI aids [129]. This concern is not unjustified, as compared to traditional methods AIguided diagnostic process can be quicker and often equally effective[130]. However, it is important to stress that AI is designed to aid medical professionals, and guidance from the Medicines and Healthcare Products Regulatory Agency (MHRA) specifies that the use of AI must not lead to a blind reliance by the operator. There are also outstanding questions surrounding patient consent and the legal implications of AI adoption[131]. For instance, in the UK, the law currently requires that consent to treatment or investigation must be obtained from the patient and any consents required have to be "fully informed"[132]. This gives rise to the question of how adequately we are able to inform patients about the nature and limitations of new AI technologies. Furthermore, the current legal framework is based on the idea of liability being attributable to human error[133]. However, decisionmaking in the context of AI is more complex because there is the possibility of whole network failure, rather than failure by an individual clinician. For this reason, some authors have suggested that a "liability share model" could be the way forward, where responsibility falls both on the supervising clinician and the manufacturer of the AI tool[134].

4.3. Challenges and barriers to widespread adoption

Moving from conventional approaches to newer and more sophisticated methods, such as those I have discussed, is not always as straightforward as might be expected[135-139]. In the case of rectal cancer detection, we have seen a range of different technologies coming to the fore, and each of them will have their own specific challenges to overcome[140]. For emerging technologies to be properly adopted in widespread usage across the board, a substantial amount of clinical and scientific research is required to prove the benefits they promise either in accuracy, patient outcome, or resource reduction and such research often takes many years to come to fruition[141]. Furthermore, the successful adoption of new technologies such as virtual colonoscopy and artificial intelligence methods will often require indepth changes to existing medical frameworks and clinical practices[142]. It is often the case, as well, that the infrastructure both physical and logistical, such as the NHS' access to the high power computing required for artificial intelligence diagnostics poses a significant barrier to adopting new technologies[143]. And, with the scientific and medical landscapes evolving at an everquickening pace, it is difficult to predict whether the next big 'revolution' in the field of rectal cancer detection is just around the corner[144]. All these factors represent potential barriers to the adoption of emerging technologies, and illustrate why it may be many years before the latest advancements become the clinical standard in rectal cancer diagnostics[145].

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