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Medical Devices in Cancer Diagnosis and Treatment: A Comprehensive Review

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Abstract: *Medical devices play a critical role in healthcare, spanning various applications from diagnosis to treatment and patient support. These devices can be categorized into three primary types: diagnostic devices, therapeutic devices, and supportive care devices. Diagnostic devices include computer-aided cancer diagnostics, biopsy tools for improved sampling, engineered nanoparticles for cancer treatment, and focal therapy for prostate cancer. Therapeutic devices encompass radiation therapy equipment, brachytherapy devices, alternating electric field therapy, and intelligent surgical tools designed for precise and efficient treatment. Supportive care devices focus on enhancing patient well-being and include vascular access devices and wearable monitors. These medical innovations contribute significantly to disease management, improving patient outcomes and quality of life.*

Keywords: Medical devices, Diagnostic Devices, Therapeutic Devices, Supportive Care Devices, Gamma Knife, Wearable Monitors.

I. INTRODUCTION

Cancer is the second leading cause of death globally and won’t be disappearing anytime[1] but several medical devices currently being researched in the field of oncology are showing promise in the detection and treatment of the disease[2].

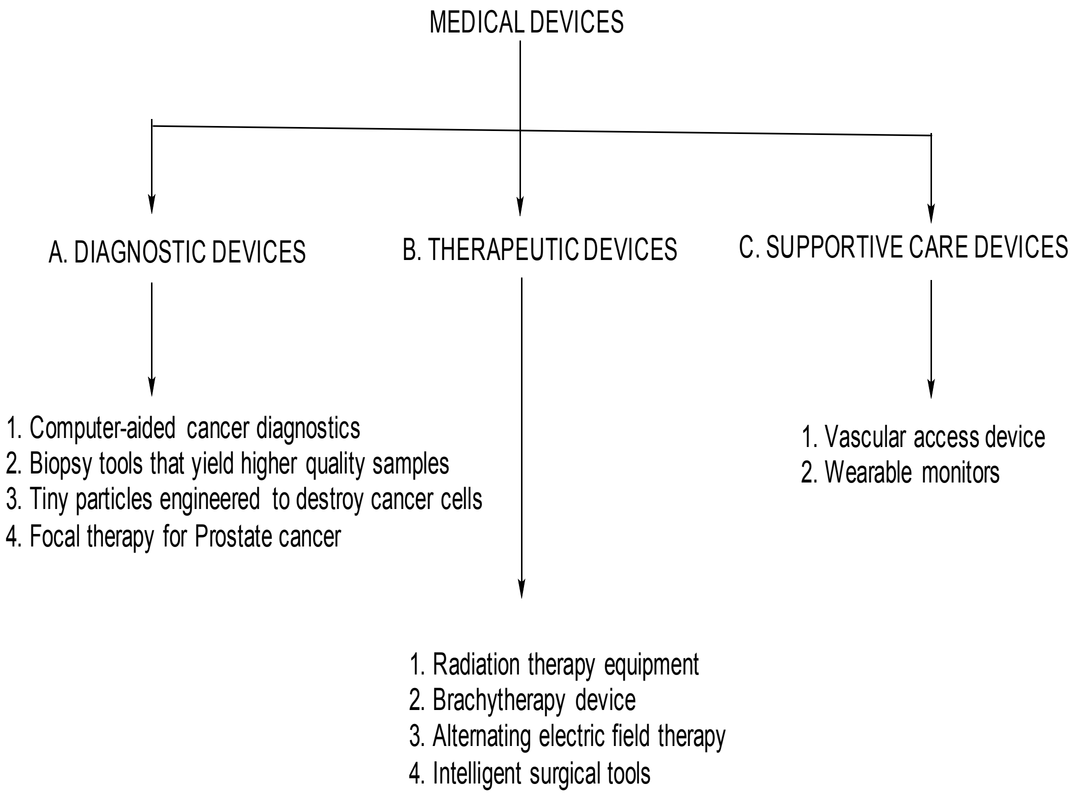
While it remains the case that many cancers can be kept away by a healthy lifestyle, statistics show that one in two people will develop the disease at some point in their lives.

While cancer researchers tend to focus on the way that drugs interact with the disease – an approach that has improved the treatment of several forms – the medical devices industry continues to look for ways to improve detection rates and treatment outcomes for patients.

From tiny nanoparticles that can deliver chemotherapy drugs directly to cancer cells, to breakthroughs in imaging technology that can better detect the disease, here are four medical devices that could be used in oncology in the future[3].

II. EMERGING MEDICAL TECHNOLOGIES IN CANCER CARE

Medical technologies play an essential role throughout the whole cancer continuum: they help prevent and detect cancer at early stages, treat patients and prevent treatment complications, as well as improve the quality of life of cancer patients and survivors[4].



DIAGNOSTIC DEVICES

Four medical diagnostic devices that could be used in oncology in the future:

1.1 Computer-aided cancer diagnostics:

Automating the diagnosis of cancer could significantly improve the availability of testing and lead to more tumors being discovered earlier, rather than later, when treatment options can become less effective.

In November, the FDA granted Breakthrough Device status to 4D Path’s precision oncology platform designed for diagnosing breast cancer.

The system uses AI to detect biomarkers for breast cancer and what the firm terms “hidden data”, like heat signatures and cell-to-cell communication, in order to rule out certain mistakes that can and are made by human histopathologists.

The significance of this technology is that rather than sending off for a hematoxylin and eosin (H&E) stain as the first of many steps, an oncology department may be able to accurately diagnose and get a prognosis for breast cancers – and hopefully other cancers in time – without needing to run other tests.

4D Path is currently undergoing validation procedures in line with FDA regulatory compliance before it can be rolled out to hospitals[5].

1.2 Biopsy tools that yield higher-quality samples:

Another barrier to efficient cancer diagnosis is the quality of biopsy samples obtained before staining and H&E testing, which is why one technology likely to proliferate in oncology departments in the future is improved biopsy tools.

An example of one of these is Precision by Israeli firm Limca Medical, which is currently validating its endoscopic biopsy device on human patients with pancreatic cancer.

The traditional method of performing an endoscopic biopsy involves putting a flexible tube called an endoscope down the throat and into the GI tract, where samples are obtained by stabbing the tumour repeatable with a tiny needle that pops out of the device.

The issue with this procedure, according to Limaca, is that it provides poor tissue samples, which affect the sensitivity of diagnostic testing, and so frequently require a second go to acquire more tissue.

Limaca's endoscopic biopsy device uses the same sort of design as standard biopsy equipment, but instead of a regular needle stab, it uses a rotational cutting implement to get a higher-quality sample that's more intact and not contaminated with blood.

In practical terms, this means less time is spent collecting and processing samples, meaning more efficiency and less waiting time between diagnosis and treatment for patients[6].

1.3 Tiny particles engineered to destroy cancer cells:

Chemotherapy and tumour removal remain the preeminent ways used in oncology to treat cancer, but researchers are currently looking into using tiny medical devices at the micro and nano scale to make the delivery of treatment a more targeted process.

In December 2020, a team from the University of Leeds in the UK released a study showing that drugs used in the treatment of cancer can be loaded onto microbubbles and ferried to cancerous cells through the blood, using monoclonal antibodies designed to seek specific locations of the tumour and deliver the payload.

Another project, this time from University College London, released findings earlier this month that showed magnetic nanoparticles could achieve a similar ambition on top of producing a heating effect that can kill cancer cells when stimulated with a magnetic field outside of the body.

This is early-stage research but it shows what could be possible in the future to make chemotherapy treatment – which is known to induce several unpleasant side effects – a more precise and less traumatic experience for patients[7].

1.4 Focal therapy for prostate cancer:

A newly-released study from Imperial College London showed that a technique known as focal therapy – the heating or cooling of tissue – can match the oncological outcomes of prostate cancer patients who have part of, or their whole, prostate removed.

The study found that in patients with non-metastatic low to intermediate prostate cancer, outcomes over 8 years were similar between focal therapy and radical prostatectomy.

The partial or full removal of the prostate is an action currently taken in patients with prostate cancer, regardless of what stage it is at, and post-surgery men can suffer from erectile dysfunction and urine incontinence as a result.

The researchers from Imperial found that using a high-intensity focused ultrasound device or cryoablation equipment to kill the cancer cells rather than removing them completely was just as effective.

Focal therapy is available already in clinical practice, but the high cost of a suite with the devices needed to perform procedures has meant a very small number of men are offered the treatment[8].

II. THERAPEUTIC DEVICES

2.1 Radiation Therapy Equipment:

Linear accelerators (linacs) deliver external beam radiation to target tumors. Elekta, a notable manufacturer, produces devices like the Versa HD linac and the Elekta Unity MR-Linac, which combines MRI imaging with radiation therapy for precise tumor targeting.

Stereotactic Radio surgery:

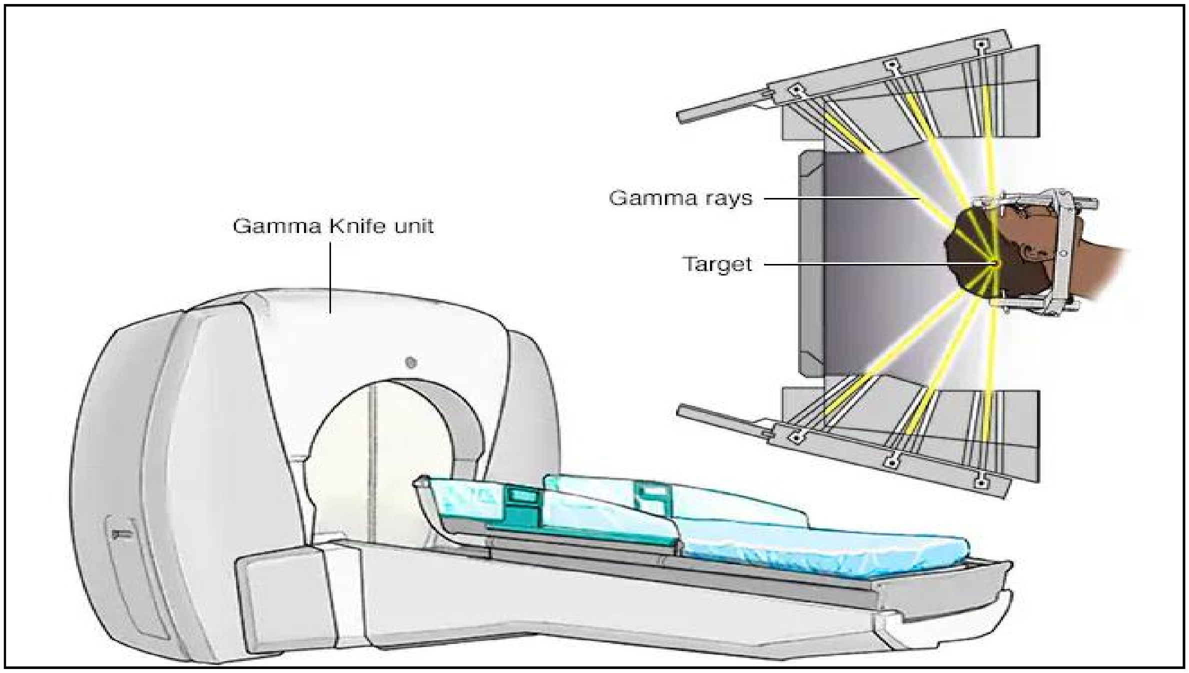
Stereotactic radio surgery utilizes externally generated ionizing radiation to inactivate or eradicate defined targets in the head or spine without the need to make an incision.[9] This concept requires steep dose gradients to reduce injury to adjacent normal tissue while maintaining treatment efficacy in the target.[10] As a consequence of this definition, the overall treatment accuracy should match the treatment planning margins of 1–2 mm or better.[11] To use this paradigm optimally and treat patients with the highest possible accuracy and precision, all errors, from image acquisition over treatment planning to mechanical aspects of the delivery of treatment and intra-fraction motion concerns, must be systematically optimized.[12] To assure quality of patient care the procedure involves a multidisciplinary team consisting of a radiation oncologist, medical physicist, and radiation therapist.[13][14] Dedicated, commercially available stereotactic radio surgery programs are provided by the irrespective Gamma Knife,[15] Cyber Knife,[16] and Novalis Radio surgery[17] devices.[18]

The Gamma Knife[19]:

Is a specialized medical device used in stereotactic radiosurgery to treat various brain conditions without the need for traditional surgical incisions. Despite its name, it doesn't involve a physical knife; instead, it utilizes precisely focused gamma radiation to target and treat specific areas within the brain.

How Gamma Knife Works:

The Gamma Knife system comprises multiple cobalt-60 sources that emit gamma rays. These rays are directed through a helmet-like device with numerous openings, allowing them to converge on a precise focal point within the brain. Each individual beam has minimal effect on the tissue it passes through, but where all beams intersect, a high dose of radiation is delivered, effectively treating the targeted area while minimizing exposure to surrounding healthy tissue.



Therapeutic Role of Gamma Knife Stereotactic Radiosurgery in Neuro-Oncology[19]

Conditions Treated with Gamma Knife:

Gamma Knife radiosurgery is employed to address various neurological conditions, including:

Brain Tumors: Both malignant and benign tumors, such as acoustic neuromas, can be treated.

Arteriovenous Malformations (AVMs): Abnormal tangles of blood vessels in the brain that can cause hemorrhages or seizures.

Trigeminal Neuralgia: A chronic pain condition affecting the trigeminal nerve in the face.

Other Functional Disorders: Certain cases of epilepsy and tremors, including those associated with Parkinson's disease.

Procedure Overview:

Preparation: A lightweight frame is attached to the patient's head to ensure precise targeting. Imaging studies, such as MRI or CT scans, are performed to locate the exact area for treatment.

Treatment Planning: Specialized software designs a treatment plan tailored to the patient's anatomy and the specific condition being treated.

Radiation Delivery: The patient lies on a treatment couch that moves into the Gamma Knife machine. The targeted area receives the planned radiation dose, with the procedure typically lasting a few hours.

Post-Treatment: Patients are usually observed for a short period and can often return to normal activities within a day or two.

Advantages of Gamma Knife Radiosurgery:

Non-Invasive: No surgical incisions are required, reducing the risk of infection and other complications.

Precision: The high accuracy of radiation delivery minimizes damage to surrounding healthy brain tissue.

Outpatient Procedure: Most treatments are completed in a single session, and patients can often go home the same day.

Gamma Knife radiosurgery represents a significant advancement in the treatment of various brain disorders, offering effective outcomes with reduced risks compared to traditional surgery.

2.2 Brachytherapy Devices:

These involve placing radioactive sources directly inside or near the tumor. Elekta's Flexitron afterloader and specific applicators for cervical cancer are examples of such devices.

Brachytherapy is a form of radiation therapy where a sealed radiation source is placed inside or next to the area requiring treatment. The word "brachytherapy" comes from the Greek word βραχύς, brachys, meaning "short-distance" or "short". Brachytherapy is commonly used as an effective treatment for cervical, prostate, breast, esophageal and skin cancer and can also be used to treat tumours in many other body sites.[20] Treatment results have demonstrated that the cancer-cure rates of brachytherapy are either comparable to surgery and external beam radiotherapy (EBRT) or are improved when used in combination with these techniques.[21][22][23] Brachytherapy can be used alone or in combination with other therapies such as surgery, EBRT and chemotherapy.

2.3 Alternating Electric Field Therapy:

Also known as Tumor Treating Fields (TTFields), this therapy uses low-intensity, intermediate-frequency electric fields to disrupt cancer cell division. Novocure's Optune device is approved for treating glioblastoma and malignant pleural mesothelioma.

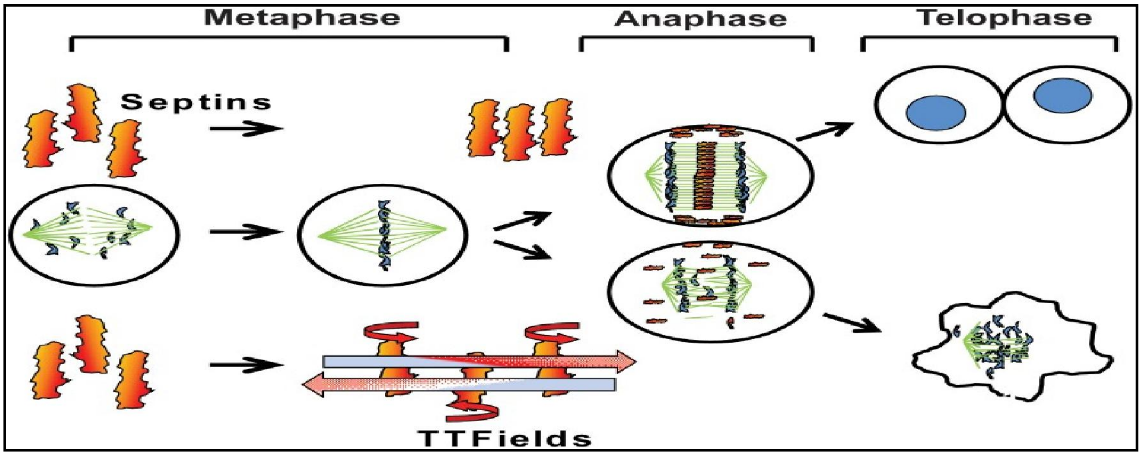
Alternating electric field therapy, sometimes called tumor treating fields (TTFields), is a type of electromagnetic field therapy using low-intensity, intermediate frequency electrical fields to treat cancer[24-27]. TTFields disrupt cell division by disrupting dipole alignment and inducing dielectrophoresis of critical molecules and organelles during mitosis. These anti-mitotic effects lead to cell death, slowing cancer growth[28-30]. A TTField-treatment device manufactured by the Israeli company Novocure is approved in the United States and Europe for the treatment of newly diagnosed and recurrent glioblastoma, malignant pleural mesothelioma (MPM), and is undergoing clinical trials for several other tumor types[31,32]. Despite earning regulatory approval, the efficacy of this technology remains controversial among medical experts[25,33].

Mechanism:

All living cells contain polar molecules and will respond to changes in electric fields. Alternating electric field therapy, or Tumor Treating Fields (TTFields) use insulated electrodes to apply very-low-intensity, intermediate-frequency alternating electrical fields to a target area containing cancerous cells[30]. Polar molecules play a key role in cell division, making mitosis particularly susceptible to interference from outside electric fields. TTFields disrupt dipole alignment and induce dielectrophoresis during mitosis, killing proliferating cells[29,34-38].

Dipole Alignment

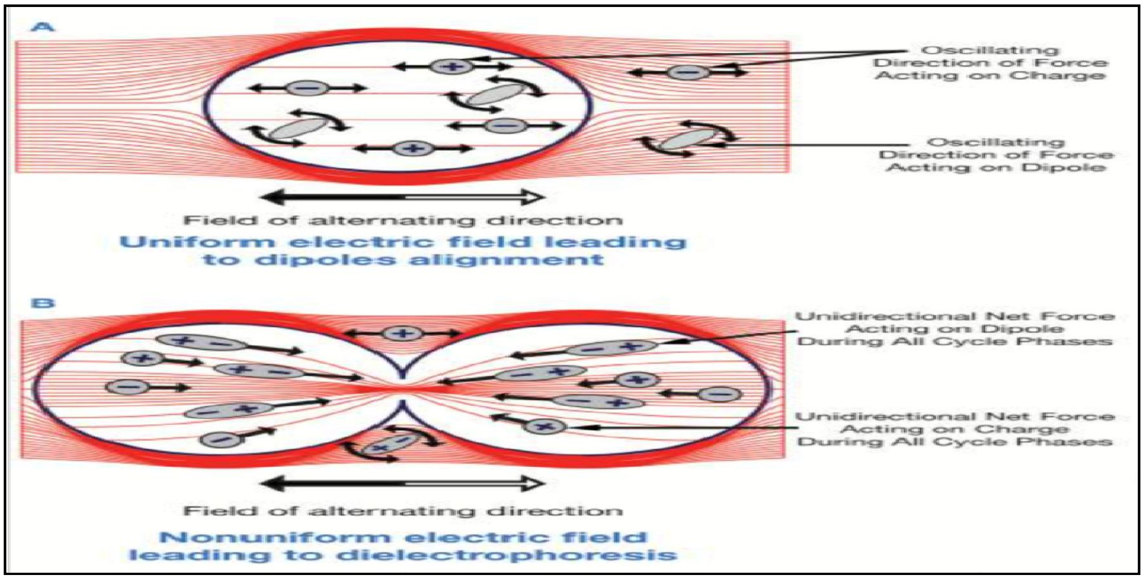
Polar molecules critical to mitosis include α/β-tubulin and the mitotic septin heterotrimer[38]. Tubulin is necessary for mitotic spindle formation during metaphase, while septins stabilize the cell during cytokinesis. When exposed to TTFields, these molecules align their dipole with the electric field, freezing them in one orientation. This prevents tubulin and septin molecules from moving to and binding where they are needed for successful cell division. This results in mitotic catastrophe, initiating cell death through apoptosis[39]. Uneven chromosome splitting can also be a result of TTFields' effect on dipole alignment, resulting in daughter cells with abnormal chromosome numbers[30,40].



Dipole molecules, such as Septins, become unable to move as needed during mitosis when exposed to TTFields, resulting in cell death[39]

Dielectrophoresis:

Cells that successfully complete metaphase are later susceptible to TTFields during Telophase[30]. At this stage in cell division, the cell takes on an hourglass shape as it prepares to divide in two. This results in a non-uniform electric field within the cell, with high field density at the cell's furrow. This causes polar molecules and organelles to migrate with the electric field toward the furrow[29,30]. This disrupts the cell's division and leads to cell death.



TTFields induce dielectrophoresis in mitotic cells[30]

Medical device:

A clinical TTFields device is manufactured by Novocure under the trade name Optune (formerly NovoTTF-100A), and is approved in the United States, Japan, Israel and multiple countries in Europe for the treatment of recurrent glioblastoma. These devices generate electromagnetic waves between 100 and 300 kHz. The devices can be used in conjunction with regular patterns of care for patients, but are only available in certain treatment centers, and require specific training and certification on the part of the prescribing physician[37,41]. When a TTFields device is used, electrodes resembling a kind of "electric hat" are placed onto a patient's shaved scalp. When not in use, the device's batteries are plugged into a power outlet to be re-charged[42].

2.4 Intelligent Surgical Tools:

The iKnife, or intelligent scalpel, analyzes tissue in real-time during surgery, helping surgeons distinguish between cancerous and healthy tissue, thereby improving surgical precision.

An onkoknife, iKnife, or intelligent scalpel is a surgical knife that tests tissue as it contacts it during an operation and immediately gives information as to whether that tissue contains cancer cells[43]. During a surgery this information is given continuously to the surgeon, significantly accelerating biological tissue analysis and enabling identification and removal of cancer cells. Electroknives have been in use since the 1920s and smart knife surgery is not limited only to cancer detection. In clinical studies the iKnife has shown impressive diagnostic accuracy - distinguishing benign ovarian tissue from cancerous tissue (97.4% sensitivity, 100% specificity)[44], breast tumour from normal breast tissue (90.9% sensitivity, 98.8% specificity)[45] and recognises histological features of poor prognostic outcome in colorectal carcinoma[46]. Furthermore, the technology behind iKnife - rapid evaporative ionisation mass spectrometry (REIMS) - can identify Candida yeasts down to species level[47].

Rapid evaporative ionization mass spectrometry:

the method is suitable for use in a surgical environment for carrying out measurements, as well as for being a part of a complex tissue identification system used during surgical tumor removal, and it can assist the surgeon in the operating surgical site with accurate histological mapping. The rapid evaporative ionization mass spectrometry (REIMS) is a novel technique that allows electro surgery cuts with near real-time characterization of human tissue in vivo analysis through analysis of the vapors released during the process of tissue and aerosols. The REIMS technology and electro-surgical procedure adds tissue diagnosis to the intelligent knife iKnife operating principle[48].

III. SUPPORTIVE CARE DEVICES

3.1 Vascular Access Devices (VADs):

Devices like peripheral intravenous catheters and central venous catheters facilitate the administration of chemotherapy and other intravenous treatments.

There are multiple vascular access device (VAD) types available for the delivery of intravenous systemic anti-cancer therapy (SACT.) The peripheral intravenous catheter/cannula (PIVC) is the most common VAD used during cancer treatment. Repeated cannulations can result in venous depletion, with peripheral vessels becoming thrombosed, resulting in the need for invasive central venous catheters[49]. Widespread use of vascular devices such as peripherally inserted central catheters (PICCs), tunnelled catheters (eg Hickman) or totally implanted ports (PORTs) is accepted. Implanted VADs or catheters can remain in place for many weeks or, in the case of ports, for years. They deliver intravenous therapeutics, medicines and fluids, and enable repeated daily blood sampling[50].

peripheral venous access devices[50]

3.2 Wearable Monitors:

Wearable devices track patients' biometric data, aiding in monitoring treatment responses and detecting potential adverse events.

Wearable health monitors have emerged as valuable tools in the supportive care of cancer patients, offering continuous monitoring of physiological parameters and aiding in treatment management.

A new trial opens in Greater Manchester today which is to test cutting-edge wearable technologies involving patients who have received cancer treatment.

The commercially-available health sensors and devices produce a digital fingerprint of vital signs that could allow doctors to assess the progress of their patients.

The trial opens initially for blood cancer, lung, and colorectal cancer patients and will run across Greater Manchester[51].

The technologies under investigation include:

A smart ring, worn on any finger made by the company Oura
The Withings Scan Watch, a hybrid smart watch
The Isansys system, which is worn on the chest.
The technologies can assess a range of vital signs, including electrocardiogram (ECG), heart rate, temperature, physical activity levels and sleep.

Wearable Monitors[53]

Wearable's and cancer treatment:

The use of wearable fitness trackers may help cancer patients and their care teams monitor activity and other vital health information so their care plans can be adjusted more quickly and effectively. Tracking symptoms and physical activity using wearable devices may result in better symptom management, fewer emergency room visits and faster recovery from treatments.

For example, high-tech wearable devices may be used to help cancer patients and their care teams:

Monitor vitals before and after oncology surgery:

Monitor symptoms, such as fatigue, nausea, low appetite and dehydration, which may help decrease the severity of treatment side effects

Track and encourage physical activity, especially following cancer treatments like chemotherapy and surgery

Patient Experiences:

Studies exploring patient experiences with wearable health monitors during cancer treatment have identified both benefits and challenges. Patients appreciate the ability to monitor their health metrics but may face barriers such as device usability and data privacy concerns.

Advancements in Wearable Technology:

Innovations continue to enhance the capabilities of wearable devices in oncology. For instance, engineers have developed an electronic finger wrap that monitors health metrics using sweat, offering a non-invasive method to track glucose and other biomarkers.

Incorporating wearable health monitors into cancer care holds promise for improving patient outcomes through personalized and continuous monitoring. Ongoing research and technological advancements are likely to expand their role in supportive cancer care.

Rehabilitation and Physical Activity:

Maintaining physical activity is crucial for cancer survivors to reduce recurrence risk and manage long-term side effects. Wearable fitness trackers encourage patients to meet exercise goals, supporting rehabilitation efforts[52].

IV. CONCLUSION

Medical technologies are playing a transformative role in cancer care, spanning from early detection to treatment and supportive care. Innovations in diagnostic devices, such as AI-powered cancer diagnostics and improved biopsy tools, are enhancing early detection and accuracy. Therapeutic advancements, including precision radiation therapy, focal treatments, and intelligent surgical tools, are improving patient outcomes while minimizing side effects. Additionally, supportive care technologies, such as wearable monitors and vascular access devices, are optimizing patient management, improving quality of life, and enabling personalized treatment approaches.

Wearable technology, in particular, is emerging as a valuable tool in cancer care, allowing continuous health monitoring, symptom tracking, and rehabilitation support. By integrating these innovations into clinical practice, cancer treatment is becoming more efficient, less invasive, and more patient-centered. As research and development continue, these medical technologies will further revolutionize oncology, offering new hope for improved survival rates and enhanced patient well-being.

REFERENCES

[1]. Roy, P. S., and B. J. Saikia. "Cancer and Cure: A Critical Analysis." *Indian Journal of Cancer*, vol. 53, no. 3, July–Sept. 2016, pp. 441–442. https://doi.org/10.4103/0019-509X.200658.

[2]. Butt, A., and H. Bach. "Advancements in Nanotechnology for Diagnostics: A Literature Review, Part II: Advanced Techniques in Nuclear and Optical Imaging." *Nanomedicine*, vol. 20, no. 2, 2024, pp. 183–206. https://doi.org/10.1080/17435889.2024.2439778.

[3]. Tiwari, Ashutosh, and Anis N. Nordin, editors. *Advanced Biomaterials and Biodevices.* Wiley, 2014. https://doi.org/10.1002/9781118774052.

[4]. Hesse, Bradford W., Daria Kwasnicka, and David K. Ahern. "Emerging Digital Technologies in Cancer Treatment, Prevention, and Control." *Translational Behavioral Medicine*, vol. 11, no. 11, 30 Nov. 2021, pp. 2009–2017. https://doi.org/10.1093/tbm/ibab033.

[5]. Vittori, G., M. Bacchiani, A. A. Grosso, et al. "Computer-Aided Diagnosis in Prostate Cancer: A Retrospective Evaluation of the Watson Elementary® System for Preoperative Tumor Characterization in Patients Treated with Robot-Assisted Radical Prostatectomy." *World Journal of Urology*, vol. 41, 2023, pp. 435–441. https://doi.org/10.1007/s00345-022-04275-x.

[6]. https://www.nsmedicaldevices.com/analysis/medical-devices-in-oncology

[7]. Zhang, Ye, Maoyu Li, Xiaomei Gao, Yongheng Chen, and Ting Liu. "Nanotechnology-Based Diagnostic Methods Are Being Developed as Promising Tools for Cancer Detection That Are Real-Time, Convenient, and Cost-Effective." *Journal of Hematology & Oncology*, 2019.

[8]. Hopstaken, Jana S., Joyce G. R. Bomers, Michiel J. P. Sedelaar, Massimo Valerio, Jurgen J. Fütterer, and Maroeska M. Rovers. "An Updated Systematic Review on Focal Therapy in Localized Prostate Cancer: What Has Changed over the Past 5 Years?" *European Urology*, vol. 81, no. 1, 2022, pp. 5–33.

[9]. Barnett, Gene H. "Stereotactic Radiosurgery—An Organized Neurosurgery-Sanctioned Definition." *Journal of Neurosurgery*, vol. 106, no. 1, 2007, pp. 1–5. https://doi.org/10.3171/jns.2007.106.1.1.

[10]. Paddick, Ian. "A Simple Dose Gradient Measurement Tool to Complement the Conformity Index." *Journal of Neurosurgery*, vol. 105, 2006, pp. 194–201. https://doi.org/10.3171/sup.2006.105.7.194.

[11]. Tsao, May N. "International Practice Survey on the Management of Brain Metastases: Third International Consensus Workshop on Palliative Radiotherapy and Symptom Control." *Clinical Oncology*, vol. 24, no. 6, 2012, pp. e81–e92. https://doi.org/10.1016/j.clon.2012.03.008.

[12]. Stereotactic Radiosurgery. Published for the American Association of Physicists in Medicine by the American Institute of Physics, 1995, pp. 6–8. ISBN 978-1-56396-497-8.

[13]. Park, Kyung-Jae. "Outcomes of Gamma Knife Surgery for Trigeminal Neuralgia Secondary to Vertebrobasilar Ectasia." *Journal of Neurosurgery*, vol. 116, no. 1, 2012, pp. 73–81. https://doi.org/10.3171/2011.8.JNS11920.

[14]. Smith, Zachary A. "Dedicated Linear Accelerator Radiosurgery for the Treatment of Trigeminal Neuralgia." *Journal of Neurosurgery*, vol. 99, no. 3, 2003, pp. 511–516. https://doi.org/10.3171/jns.2003.99.3.0511.

[15]. Lindquist, Christer. "The Leksell Gamma Knife Perfexion and Comparisons with Its Predecessors." *Neurosurgery*, vol. 61, 2007, pp. ONS130–ONS141. https://doi.org/10.1227/01.neu.0000316276.20586.dd.

[16]. Adler, John. "The Future of Robotics in Radiosurgery." *Neurosurgery*, vol. 72, 2013, pp. A8–A11. https://doi.org/10.1227/NEU.0b013e318271ff20.

[17]. Wurm, Reinhard. "Novalis Radiosurgery Frameless Image-Guided Noninvasive Radiosurgery: Initial Experience." *Neurosurgery*, vol. 62, no. 5, 2008, pp. A11–A18. https://doi.org/10.1227/01.NEU.0000325932.34154.82.

[18]. Andrews, David. "A Review of Three Current Radiosurgery Systems." *Surgical Neurology*, vol. 66, no. 6, 2006, pp. 559–564. https://doi.org/10.1016/j.surneu.2006.08.002.

[19]. Desai, R., et al. "Therapeutic Role of Gamma Knife Stereotactic Radiosurgery in Neuro-Oncology." *National Center for Biotechnology Information (NCBI)*, 2020, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7023953/.

[20]. Gerbaulet, A., R. Pötter, J. J. Mazeron, H. Meertens, and V. Limbergen, editors. *The GEC ESTRO Handbook of Brachytherapy.* European Society for Therapeutic Radiology and Oncology, 2002.

[21]. Viswanathan, A. N., et al. "Gynecologic Brachytherapy." *Brachytherapy: Applications and Techniques*, edited by P. Devlin, Lippincott Williams & Wilkins, 2007.

[22]. Kishan, Amar U., Ryan Cook, Jay P. Ciezki, et al. "Radical Prostatectomy, External Beam Radiotherapy, or External Beam Radiotherapy with Brachytherapy Boost and Disease Progression and Mortality in Patients with Gleason Score 9-10 Prostate Cancer.” *JAMA*, vol. 319, no. 9, 2018, pp. 896–905. https://doi.org/10.1001/jama.2018.0587.

[23]. Pieters, Boudewijn R., D. Z. De Back, C. C. Koning, and A. H. Zwinderman. “Comparison of Three Radiotherapy Modalities on Biochemical Control and Overall Survival for the Treatment of Prostate Cancer: A Systematic Review.” *Radiotherapy and Oncology*, vol. 93, no. 2, 2009, pp. 168–173. https://doi.org/10.1016/j.radonc.2009.08.033.

[24]. Romney, Oluwatobi, Ann Vanderlinden, S. J. Clenton, et al. “Tumour Treating Fields Therapy for Glioblastoma: Current Advances and Future Directions.” *British Journal of Cancer*, vol. 124, no. 4, 2020, pp. 697–709. https://doi.org/10.1038/s41416-020-01136-5.

[25]. "NCCN Guidelines for CNS Cancers." *National Comprehensive Cancer Network*, Retrieved 4 Aug. 2013.

[26]. Kirkpatrick, John. “Recurrent Malignant Gliomas.” *Seminars in Radiation Oncology*, vol. 24, no. 4, Oct. 2014, pp. 289–298. https://doi.org/10.1016/j.semradonc.2014.06.006.

[27]. Johnson, David. “Medical Management of High-Grade Astrocytoma: Current and Emerging Therapies.” *Seminars in Oncology*, vol. 41, no. 4, Aug. 2014, pp. 511–522.

[28]. Tuszynski, Jack A., Christine Wenger, Derek E. Friesen, and Joana Preto. “An Overview of Sub-Cellular Mechanisms Involved in the Action of TTFields.” *International Journal of Environmental Research and Public Health*, vol. 13, no. 11, 12 Nov. 2016, p. 1128. https://doi.org/10.3390/ijerph13111128.

[29]. Mun, Eugene J., Huma M. Babiker, Uriel Weinberg, et al. “Tumor-Treating Fields: A Fourth Modality in Cancer Treatment.” *Clinical Cancer Research*, vol. 24, no. 2, 15 Jan. 2018, pp. 266–275. https://doi.org/10.1158/1078-0432.CCR-17-1117.

[30]. Hottinger, Andreas F., Priscilla Pacheco, and Roger Stupp. “Tumor Treating Fields: A Novel Treatment Modality and Its Use in Brain Tumors.” *Neuro-Oncology*, vol. 18, no. 10, Oct. 2016, pp. 1338–1349. https://doi.org/10.1093/neuonc/now182.

[31]. "ClinicalTrials.gov Results - Novocure." *ClinicalTrials.gov*, U.S. National Library of Medicine, Retrieved 26 Dec. 2014.

[32]. "Using Tumor Treating Fields to Combat Mesothelioma." *Mesothelioma Center - Vital Services for Cancer Patients & Families*, Retrieved 4 Dec. 2023.

[33]. Wick, Wolfgang. "TTFields: Where Does All the Skepticism Come From?" *Neuro-Oncology*, vol. 18, no. 3, 25 Feb. 2016, pp. 303–305. https://doi.org/10.1093/neuonc/now012.

[34]. Calzón Fernández, S., and A. Llanos Méndez. *Tumor Treating Fields Therapy (TTFields) for Glioblastoma: A Systematic Review of the Literature.* Agencia de Evaluación de Tecnologías Sanitarias de Andalucía, 2013. ISBN 978-84-15600-12-1.

[35]. Kirson, E. D., et al. "Disruption of Cancer Cell Replication by Alternating Electric Fields." *Cancer Research*, vol. 64, no. 9, 1 May 2004, pp. 3288–3295. https://doi.org/10.1158/0008-5472.CAN-04-0083.

[36]. Kirson, E. D., et al. "Alternating Electric Fields Arrest Cell Proliferation in Animal Tumor Models and Human Brain Tumors." *Proceedings of the National Academy of Sciences (PNAS)*, vol. 104, no. 24, 12 June 2007, pp. 10152–10157. https://doi.org/10.1073/pnas.0702916104.

[37]. Mrugala, Maciej M. "Advances and Challenges in the Treatment of Glioblastoma: A Clinician's Perspective." *Discovery Medicine*, vol. 15, no. 83, 25 Apr. 2013, pp. 221–230.

[38]. Swanson, K., et al. "An Overview of Alternating Electric Fields Therapy (NovoTTF Therapy) for the Treatment of Malignant Glioma." *Current Neurology and Neuroscience Reports*, vol. 16, no. 1, 2016, p. 8. https://doi.org/10.1007/s11910-015-0606-5.

[39]. Gera, N., et al. "Tumor Treating Fields Perturb the Localization of Septins and Cause Aberrant Mitotic Exit." *PLOS ONE*, vol. 10, no. 5, 2015, e0125269. https://doi.org/10.1371/journal.pone.0125269.

[40]. "Tumor Treating Fields." *XVIVO Scientific Animation*, Retrieved 21 Nov. 2023.

[41]. Batchelor, T., H. Shih, and B. Carter. "Management of Recurrent High-Grade Gliomas." *UpToDate*, Retrieved 26 Dec. 2014.

[42]. Herper, Matthew. "Cancer-Fighting Electric Hat Proves We Live in the Future." *Forbes*, 15 Apr. 2011.

[43]. Balog, J., et al. "Intraoperative Tissue Identification Using Rapid Evaporative Ionization Mass Spectrometry." *Science Translational Medicine*, vol. 5, no. 194, 2013, p. 194ra93. https://doi.org/10.1126/scitranslmed.3005623.

[44]. Phelps, David L., et al. "The Surgical Intelligent Knife Distinguishes Normal, Borderline, and Malignant Gynaecological Tissues Using Rapid Evaporative Ionisation Mass Spectrometry (REIMS)." *British Journal of Cancer*, vol. 118, no. 10, May 2018, pp. 1349–1358. https://doi.org/10.1038/s41416-018-0048-3.

[45]. St John, Edward R., et al. "Rapid Evaporative Ionisation Mass Spectrometry of Electrosurgical Vapours for the Identification of Breast Pathology: Towards an Intelligent Knife for Breast Cancer Surgery." *Breast Cancer Research*, vol. 19, no. 1, Dec. 2017, p. 59. https://doi.org/10.1186/s13058-017-0845-2.

[46]. Alexander, James, et al. "A Novel Methodology for In Vivo Endoscopic Phenotyping of Colorectal Cancer Based on Real-Time Analysis of the Mucosal Lipidome: A Prospective Observational Study of the iKnife." *Surgical Endoscopy*, vol. 31, no. 3, Mar. 2017, pp. 1361–1370. https://doi.org/10.1007/s00464-016-5121-5.

[47]. Cameron, Simon J. S., et al. "Rapid Evaporative Ionisation Mass Spectrometry (REIMS) Provides Accurate Direct-from-Culture Species Identification Within the Genus Candida." *Scientific Reports*, vol. 6, no. 1, Dec. 2016, p. 36788. https://doi.org/10.1038/srep36788.

[48]. Balog, J., et al. "Intraoperative Tissue Identification Using Rapid Evaporative Ionization Mass Spectrometry." *Science Translational Medicine*, vol. 5, no. 194, 2013, p. 194ra93. https://doi.org/10.1126/scitranslmed.3005623.

[49]. Ray-Barruel, G., and M. Alexander. "Evidence-Based Practice for Peripheral Intravenous Catheter Management." *American Journal of Nursing*, vol. 123, no. 1, 2023, pp. 32–37. https://doi.org/10.1097/01.NAJ.0000905568.37179.01.

[50]. Pittiruti, M., T. Van Boxtel, and G. Scoppettuolo. "European Recommendations on the Proper Indication and Use of Peripheral Venous Access Devices (the ERPIUP Consensus): A WoCoVA Project." *Journal of Vascular Access*, vol. 24, no. 1, 2023, pp. 165–182. https://doi.org/10.1177/11297298211023274.

[51]. Chow, Ronald, et al. "The Use of Wearable Devices in Oncology Patients: A Systematic Review." *The Oncologist*, vol. 29, no. 4, Apr. 2024, pp. e419–e430. https://doi.org/10.1093/oncolo/oyad305.

[52]. Collinson, S., et al. "Patient Experiences of Using Wearable Health Monitors During Cancer Treatment: A Qualitative Study." *Clinical Oncology*, vol. 37, 2024, p. 103664.

[53]. "Trial of Wearable Health Technology for Cancer Patients." *The University of Manchester*, https://www.manchester.ac.uk/about/news/trial-of-wearable-health-technology-for-cancer-patients.