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RESEARCH ARTICLE

Advancements in Molecular Imaging for the Diagnosis and Management of Hepatocellular Carcinoma

Farshid Gheisari[1], *Reza Vali[2]

1. Ionizing and Non-ionizing Radiation Protection Research Center (INIRPRC), Shiraz University of Medical Sciences, Shiraz, Iran
2. Diagnostic Imaging, Nuclear Medicine Division, The Hospital for Sick Children, University of Toronto, Toronto, Ontario, Canada

***Corresponding Author:** Reza.vali@sickkids.ca

ABSTRACT:
Hepatocellular Carcinoma (HCC) is a growing global health burden with high incidence and mortality rates. Despite advances in surgical techniques and perioperative care, outcomes after surgical treatment have not improved over the past three decades. Molecular imaging is an emerging field that enables researchers to study diseases at the molecular and cellular levels, enabling the detection of elevated serum α-fetoprotein (AFP) and abnormal expressions of various HCC-specific and nonspecific cell surface antigens and intracellular targets. Molecular imaging techniques detect liver lesions at the molecular and cellular level, allowing early detection and accurate staging of HCC. Positron emission tomography (PET) imaging offers greater sensitivity and specificity, while hepatobiliary-specific radiotracers with SPECT imaging provide insights into benign and malignant lesion differentiation. Radiomics and artificial intelligence are vital in deciphering molecular imaging data, with machine learning algorithms boosting diagnostic gains and predicting treatment response. Theranostics, a state-of-the-art application, provides diagnostic and therapeutic leverage following a single imaging agent. By understanding tumor biology in real time, radiopharmaceuticals can be transformed into personalized radiotherapies, enabling clinicians to make science-driven decisions throughout the illness. Future directions include developing novel radiotracers and integrating AI into clinical decision-making. Collaboration between academic researchers, clinicians, and industry colleagues is crucial to converting exciting advances into improved clinical outcomes for HCC patients.

Keywords: Hepatocellular Carcinoma, Molecular Imaging, Positron Emission Tomography, Single-Photon Emission Computed Tomography, Radiomics, Theranostics, Artificial Intelligence.

Introduction:

The diagnostic landscape of hepatocellular carcinoma (HCC), the most common form of liver cancer, has been continually changing since the advent of molecular imaging. Knowing the historical context surrounding molecular imaging and how it relates to HCC provides a basis to gauge the difficulties in the past, the successes, and the future of the technology.[1] Molecular imaging in HCC has a relatively short history, with the advent of conventional imaging during the last half of the 20th century. Conventional imaging tools such as ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) have played dramatic roles in detecting and characterizing liver lesions. However, to improve the detection of liver tumors and obtain more than anatomic detail, novel imaging research must demonstrate the added value of providing molecular and functional information above and beyond that of conventional imaging tools.[2] Hepatocellular carcinoma (HCC) of the liver is a malignant neoplasm originating from either hepatocytes or hepatocyte precursors. Liver cancer is a deadly and often leading type of cancer, with almost 80000 Americans being diagnosed with it each year. The treatment options for HCC primarily depend on the disease stage. Still, they may include surgical therapies such as radiofrequency ablation or liver transplantation, as well as locoregional therapies (chemoembolization, radioembolization) and systemic therapies (sorafenib). As a result of the higher prevalence of HCC in populations at risk, as well as the higher mortality of this disease state when compared to many other abdominopelvic cancers, there have been substantial efforts made to accurately and rapidly diagnose HCC.[3] The true revolution in molecular imaging of HCC began with the advent of Positron Emission Tomography (PET) in the 1990s. PET was first used for whole-body staging of various cancers. PET came to liver imaging with the advent of radiotracers that reflect cellular glucose metabolism, such as the 18F-FDG. Although initial studies of 18F-FDG PET imaging of HCC were not efficient enough to be applied in HCC due to the variable glucose metabolism of well-differentiated HCC, they laid the foundation for future developments.[4] With the developing understanding of the molecular basis of HCC, researchers quickly realized the need for a more tailored approach to imaging these lesions and, therefore, began developing radiotracers specific for the molecular pathways that drive this tumor. Biomarkers such as glypican-3 (GPC3) and alpha-fetoprotein (AFP) were discovered, and radiotracers were developed to bind these markers specifically to HCC lesions.[5] Concurrently, functional imaging with SPECT using hepatobiliary-specific radiotracers became another new imaging tool to help with HCC diagnosis. SPECT, in particular, has the advantage of providing both functional and anatomic information and can, therefore, help identify the functional state and the dynamic changes in HCC within the liver.[6] Integrating AI and Radiomics into molecular imaging studies in the early 21st century offered an additional leap forward. As computational power came online from these technologies, it enabled the analysis of staggering datasets from molecular imaging studies. It revealed behind-the-scenes patterns that provide a more granular picture of HCC characteristics.[7] The concept of Theranostics in the late 1980s was painted after the declaration of the 21st Century; it was based on Theranostics as a combination of therapeutic and diagnostic functions in a single imaging agent. Its implementation has increased the promise that the HCC can receive the best assessment, treatment, and targeted therapy delivered directly to the cancer cells.[8] It is easy to see that each era of molecular imaging in HCC has been marked by an increase in the molecular clarity of HCC and the quest for new and more exact, personal, and dynamic diagnosis and treatment strategies. These will serve as our starting points as we explore these segments.[9]

Importance of Early Detection:

The early detection of HCC is the key to attaining better patient outcomes. Detecting the tumor at an earlier stage can significantly impact the timing of different intervention strategies, and it may increase the chance of other options for treatment, which may lead to a better survival rate.[10] The earliness of diagnosis, reception to intervention strategy, or the aptitude for liver resection or transplantation all together determine the overall success and survival rates of patients with HCC.[11] In this context, molecular imaging offers various methods, including specific imaging techniques and developing contrast materials. This type of medical imaging can classify liver lesions at cellular and molecular levels, which should possess the relationship between HCC and liver cirrhosis. Advanced imaging can identify clockwise advanced HCC, tiny tumors, and the beginning of HCC thirteen.[12-13] Molecular imaging uses the molecular signatures of normal and diseased cells to detect what ails the cell years before the disease develops.[14] Doing this gives us a much earlier look at the actual HCC disease and allows for a tailored proactive therapy involving the right drugs and short surgery times.[15] An added advantage of molecular imaging is the ability to identify small tumors and early-stage disease, particularly in populations at high risk of developing HCC, such as persons with chronic liver disease (CLD), particularly cirrhosis.[16] In a high-risk population, where the transition from liver disease to HCC is a known problem, early identification then becomes an essential linchpin in managing these patients.[17] The recognition of HCC lesions in the liver of patients with chronic liver diseases is significant. With molecular imaging, it becomes more feasible, often in patients with chronic liver diseases, which leads to an increased risk for HCC development.[18] However, the prognosis is favorable if HCC can be diagnosed efficiently. Many treatment options are available, such as surgical resection, ablation techniques including percutaneous ethanol injection and Radiofrequency ablation, and newer, targeted therapies.[19-20] The importance of early detection is evident in its ramifications, which supersedes the simple notion of finding HCC. With its ability to uncover the molecular background of liver lesions, introducing molecular imaging allows it to become a pivot point in a patient's new care. Allowing for earlier diagnosis ultimately allows us as healthcare providers to meet the patient's needs more proactively and personally, ultimately improving patient outcomes and quality of life.

Positron Emission Tomography (PET) Imaging:

Newer advanced diagnostic modalities, such as Positron Emission Tomography (PET) imaging and specific radiotracers, provide metabolic information about a lesion differently than traditional imaging methods.[21] By using PET imaging, healthcare professionals can see information about the metabolic activity within liver lesions. To gain a complete evaluation of Hepatocellular Carcinoma (HCC), it is necessary to know the metabolic activities in liver lesions.[22] Radiotracers, such as 18F-FDG, have played a key role historically in oncology imaging; however, they have had limited success within HCC, likely owing to the variable glucose metabolism of liver lesions.[23] More recently, advances in PET imaging have ushered in the development of novel radiotracers designed explicitly to target specific molecular pathways involved in HCC.[24] This has manifested with tailored radiotracers designed to identify - through various imaging modalities - specific biomarkers that have been noted to closely associate with hepatocellular carcinoma, such as glypican-3 (GPC3) and alpha-fetoprotein (AFP) [25], making it more intricate than previously understood tracer studies where non-specific radiotracers were mainly used (e.g., computerized tomography scan using triple-phase liver enhancement).[26] As a result, it offers better sensitivity and specificity than its competitors in providing more accurate and precise detection of hepatocellular carcinoma, thereby overcoming the limitation of variable glucose metabolism.[27] Therefore, it regards the existing conventional diagnostic tools in making an accurate and reliable diagnosis as the invention of target radiotracers, which has revolutionized the diagnostic modality of HCC where conventional diagnostic modalities lack the sensitivity to diagnose the disease.[28] Targeting the molecular pathway that is specifically involved in the development of hepatocellular carcinoma, these target radiotracers offer a unique molecular imaging technique to look into the subtle metabolic changes that can occur in smaller tumors or even in tumors of a larger size that can escape the diagnostic ability of the standard radiological imaging techniques.[29] Furthermore, PET, in conjunction with dedicated radiotracers, offers advantages beyond simple diagnostic ability: it allows the identification of specific molecular markers that are present on HCC cells, which could help in the evaluation of the lesions in terms of the probability of being malignant or benign, their malignancy grading, and the response to the potential treatment.[30] With these innovative radiotracers focused on the molecular pathways specific to HCC; this concept can significantly help personalized medicine against hepatocellular carcinoma.[31] In conclusion, PET allows for improved diagnostic accuracy with these dedicated radiotracers.[32] It is the direct consequence of this increased sensitivity and sensitivity as this pure imaging technique can overcome previous inherent issues, especially protuberant limitations, and thus results in more precise and personalized screening and characterization by our tumor of interest, HCC.[33]

Single-Photon Emission Computed Tomography (SPECT) Imaging:

Single-photon emission Computed Tomography (SPECT) imaging, when paired with hepatobiliary-specific radiotracers like 99mTc-mebrofenin, is a robust modality in hepatocellular carcinoma (HCC) diagnostics.[34] While traditional imaging techniques only consider structural details, SPECT imaging captures information on liver physiology, going deeper into its functional details.[35] This unique approach adds value by speaking to the dynamic and holistic nature of the liver and has ramifications for liver imaging, particularly in HCC screening and other conditions.[36] The concept of hepatobiliary-specific radiotracers in SPECT imaging introduces another objectively-based clinical insight important to hepatic lesion evaluation.[37] On the other hand, SPECT provides functional information besides visualizing lesions. Benign and malignant lesions are differentiated by gauging the influx dynamics of 99mTc-mebrofenin uptake.[38] This method's ability improves the accuracy of diagnosis by characterizing a lesion and guiding treatment.[39-40] SPECT can also do more than identify HCC; it can also see how the liver functions. This is useful because it evaluates the liver's health more entirely for those with HCC.[41] This complete understanding of liver function contributes significantly to the bigger picture: HCC treatment strategies and how each is tailored to fit certain patients and diseases.[42] SPECT clinical examinations distinguish the liver and how the entire liver deals with HCC.[43] The functional information gathered from SPECT imaging contributes to the diagnosis, disease progression, and treatment outcome.[44] By providing real-time functional data of the liver, SPECT helps provide a holistic, adaptative strategy in handling patients because of the dynamic nature of Hepatocellular Carcinoma (HCC); this can be a particularly useful tool in addressing concerns concerning the ongoing evolution of the disease.[45] In summary, when coupled with hepatobiliary radiotracers, SPECT imaging is a valuable and necessary tool in diagnosing HCC.[46] The unique ability of nuclear imaging to provide functional information about liver physiology, which in turn enables differentiation of hepatocellular carcinoma from other liver lesions, is the same property of the technique that puts it in a pivotal role in the quest for authentic, personalized, and dynamic management strategies of hepatocellular carcinoma.

Role of Radiomics and Artificial Intelligence:

The introduction of artificial intelligence (AI) and radiomics into the field of hepatocellular carcinoma (HCC) diagnostics is a game changer in practice. It is fair to say that this new technology can interpret molecular imaging data to heights that no one has previously predicted.[47] The use of AI will have a significant impact on HCC with machine learning algorithms and other types, which should not be confused with the use of AI to improve the interpretability of the radiomics features in the Images to analyze the big data sets that are generated from molecular imaging-based studies to help significantly improve the diagnosis and the sexuality of the HCC prognostic response.[48] Machine learning techniques have been helpful when looking at large amounts of data for more complex patterns. Machine learning techniques have gained considerable attention in the medical field, including in the hepatocellular carcinoma treatment sphere.[49] Given the ability to analyze complex data sets as a machine and identify patterns within these data sets, machine learning algorithms are an excellent aid for diagnosis, especially for those with very complex data sets. These are some of the various readings that can be read: the metabolic activity and molecular imaging types seen on different occasions.[50] Moreover, these algorithms are generally excellent predictors of therapy response. This is especially applicable before therapy begins, confirming whether or not a treatment shall be used before exposure to the drug.[51] Radiomics is a complementary field that expands on molecular imaging and its diagnostic applications in HCC.[52] It involves extracting quantitative features from medical images that may not be visible to the human eye – unveiling hidden information.[53] Regarding HCC, radiomics detects complex imaging features that are potential biomarkers for improved risk stratification.[54] Radiomics provides granular data, bringing capabilities to uncover the disease early, better differentiate tumor heterogeneity, and subtle changes that mark disease progress.[55] This union of AI and Radiomics promises a new era of personalized medicine in HCC.[56] This is so because the applications of AI and Radiomics can crunch the massive amount of imaging data associated with high dimensional analysis to fully understand, implement, and propose tailored treatments based on the patient's characteristics.[57] This improvement can increase diagnostic accuracy and a deeper understanding of the disease, allowing for treatment plans to be more specific to the characteristics of an individual's HCC.[58] The rapid AI developments are leading to a fast incorporation of molecular imaging as part of routine clinical work.[59] This knowledge can help us make clinical decisions and fully take advantage of the potential of the molecular imaging body.[60] With an increasing shift to making diagnoses from the traditional routine to an AI, computational radiologists integrated technology, personalizing, and the most specific treatment to highlight some of the most significant structural, combined, and most successful care and modes were fast track to a new era of the most direct, individual treatment to his career.[61] This blend of skills in artificial intelligence radiomics and molecular imaging can help researchers get a more detailed look at the best treatment for these patients. With increased research and treatment for HCC, researchers and physicians may change the outcome and treatment of these patients.[62]

Theranostics in HCC:

The paradigm-shifting concept of theranostics combines diagnosing and treating hepatocellular carcinoma (HCC) in a single imaging agent.[63] In the HCC realm of theranostics, radiolabeled compounds combine diagnostic imaging with target treatment.[64] In surpassing traditional diagnostics and treatments, this revolution in integrated diagnostics and patient care treatment is groundbreaking.[65] For HCC imaging, radiolabeled compounds have a dual role as a diagnostic tool in enabling accurate visualization and characterization of HCC lesions.[66] This helps obtain extra information regarding the lesion, aiding in precise disease staging and offering information for tumor-specific targets.[67] In addition, this plethora of information sharing allows better differentiation of HCC from the cirrhotic liver and diagnosis. The development of such advanced imaging modality has increased the diagnostic confidence of HCC and subsequently affected physicians in planning the optimal curable therapy protocols.[68] At the same time, theranostics is based on its radio-labeled compounds for targeted therapy, and it is a new approach to HCC treatment.[69] The Direct transmission of therapy with theranostics to the cancer cells rather than the waste of healthy cells or other tissues resulted in damage.[70] It is held that targeted cellular therapies accounted for many therapies the belief system is attributed to based LEIC receptor on tyrosine kinase signaling pathways, among others.[71] The potential reduction in side effects associated with systemic treatments also supports the notion that theranostics improves the quality of life for HCC patients.[72] The integration of theranostics in HCC reflects how theranostics can radically change personalized patient care by personalizing treatments based on each patient's specific case.[73] Identifying targets unique to the tumor enables more targeted treatment and allows immediate monitoring of how far the therapy works.[74] This era's precision oncology paradigm incorporates patient selection and treatment monitoring through molecular aberrations. Furthermore, this real-time feedback loop helps with the ability of therapy strategy to change because of the dynamic nature that displayed the disease, and this, in the course, helps to fuel a new personalized and adaptive Theranostic management of HCC.[75] Theranostics is a more novel treatment for patients with HCC, which is significantly better and more innovative than most other treatment classes used today.[76] The convergence of diagnostic and therapeutic entities could create the ability to advance hepatocellular carcinoma precision medicine.[77] The future of theranostic research is as intriguing as it is, and the potential impact this discipline could make upon improving patient outcomes and perhaps even prognosis in hepatocyte carcinoma indeed represents an exciting advancement in Liver cancer therapeutics.[78]

Monitoring Treatment Response:

To guide therapy and assess treatment response, molecular imaging plays a crucial role in the fast-paced landscape of hepatocellular carcinoma (HCC) management.[79] This is key for any imaging modality, ranging from the standard contrast-enhanced CT to the vast array of advanced molecular imaging.[80] Whatever the modality, the capacity to track the changes in tumor biology as time passes gives clinicians valuable understanding and helps them to navigate the complex roadmap for treating HCC.[81] Many traditional imaging modalities, such as contrast-enhanced CT, are non-imaging biomarkers and are relied upon for anatomical detail in evaluating tumor size and vascularity changes.[82] By incorporating advanced molecular imaging techniques, imaging biomarkers elevate the ability to monitor and follow treatment response at a molecular level. Molecular imaging allows a deeper understanding of tumor biology's molecular and cellular characteristics.[83] Utilizing positron emission tomography (PET) with targeted radiotracers or single-photon emission computed tomography (SPECT) with hepatobiliary-specific agents, molecular imaging goes beyond defining the changes within the tumor microenvironment.[84] This includes metabolic changes, lesions, and the cellular count being higher or lower than usual, which can all be markers of therapy progression.[85] This highly detailed, specific information allows doctors to evaluate whether their current therapy works or if any problems, such as resistant tumor clones or new lesions, might occur.[86] Molecular imaging is part of the future of care planning because it gives accurate, real-time data that lets doctors make up-to-the-minute changes to current care plans.[87] Clinicians can adapt therapies quickly in response to the evolving molecular architecture of the disease to improve their chances of success.[88] By conducting treatment in this dynamic manner, patients receive an intervention tailored to their particular HCC, which maximizes the potential for the patient to benefit.[89] The use of molecular imaging for real-time monitoring enables decisions to be made in the future based on data rather than on the efficacy of a treatment that may or may not be improving the disease state.[90] This approach reduces the delay in adapting the treatment plan. Adjustments are made and managed in real-time, as such traits are essential in a disease whose progression is swift.[91] Ultimately, this technique and this approach confirm and increase the success of therapeutic interventions, quality of life, and patient outcomes.[92] Integrating molecular imaging into monitoring treatment response in HCC represents a transformative advancement. Molecular Imaging allows physicians to assess tumor biology at the molecular level for real-time evaluation of therapy efficacy or to guide decisions.[93] These technological advances in imaging through which patients with

HCC are cared for are examples of a new way of thinking toward personalized and dynamic treatment strategies in HCC, another big step to reaching better outcomes in patients with hepatocellular carcinoma.[94-95] Table 1 summarizes the molecular imaging techniques used in diagnosing and managing hepatocellular carcinoma.

Table 1: Molecular Imaging Technologies in HCC Diagnosis and Management

Molecular Imaging Modality	Key Features	Applications in HCC
Positron Emission Tomography (PET)	Utilizes specific radiotracers for enhanced metabolic activity imaging	Improved detection, accurate staging, and targeted therapeutic planning
Single-photon emission Computed Tomography (SPECT)	Uses hepatobiliary-specific radiotracers for functional insights	Comprehensive assessment of liver physiology, differentiation of benign and malignant lesions
Radiomics and Artificial Intelligence	Machine learning algorithms analyze complex datasets	Improved interpretation, precise risk stratification, and personalized treatment planning
Theranostics	Integrates diagnostic and therapeutic capabilities within a single imaging agent	Targeted therapy, real-time monitoring, and personalized treatment strategies

Challenges and Future Directions:

Despite the advancement in the molecular imaging techniques for HCC, there are several vital challenges where more research is warranted to refine the molecular imaging protocols and have more widespread use.[96] The most important among those is standardizing the imaging protocols. Due to the wide variability of imaging techniques and methodologies across different institutions, the results become less comparable.[97] Therefore, having a commonly accepted imaging protocol leads to better consistency and reliability in HCC diagnostics and provides a better holistic approach to patient care.[98] Moreover, another critical challenge of imaging HCC is the accessibility of state-of-the-art imaging technologies from lab to clinic.[99] The widespread adoption of these state-of-the-art molecular imaging techniques is challenged by the costs associated with whole-body imaging hardware and software and the need for the infrastructure to support whole-body imaging.[100] It is essential to bridge the gap in accessibility to whole-body imaging across the healthcare spectrum to enable equitable access to the benefits these state-of-the-art molecular imaging techniques can offer patients.[101] Extensive clinical validation studies are required to prove the robustness and reliability of these molecular imaging modalities in a diverse group of patients.[102] Whole-body imaging techniques must be tested in a comprehensive study with a patient spectrum covering a broad demographic and a vast range of hepatic disease stages to demonstrate their true efficacy in real-world scenarios.[103] The current studies may enhance our knowledge of the diagnostic and prognostic potential of molecular imaging in HCC, and the results of these clinical trials can lay the groundwork for evidence-based guidelines in HCC clinical practice.[104] However, new specific radiotracers for emerging molecular markers associated with HCC require development [105]; for each of the HCC biomarkers that have been newly discovered to reflect the complicated biological behavior of HCC lesions, using novel radiotracers that can be targeted presents an opportunity to report more accurate diagnoses and guide treatment strategy.[106] This innovation will remarkably enhance the sensitivity and specificity of molecular imaging and provide clinicians with more concrete information to guide their clinical decision-making.[107] The integration of artificial intelligence (AI) is another future feature of molecular imaging for HCC.[108] AI algorithms can improve the accuracy of diagnosis, simplify the interpretation of images, and help recognize the invisible patterns in the initial stages of the disease.[109] The joining of AI and molecular imaging may promise the next level of sophistication of HCC diagnostics.[110] Expansion of theranostics application is also of interest.[111] This would involve greater incorporation of diagnostic and therapeutic elements within one imaging agent and the designs of treatments that are individual to the molecular make-up of the patient's tumor.[112] By aiming to maximize the effect on tumors while minimizing adverse effects, theranostics is most attractive for HCC in the age of personalized medicine.[113] Collaboration between researchers, clinicians, and industry stakeholders is critical to overcoming these barriers and successfully implementing imaging into patient care.[114] Standardized protocols should be developed through multidisciplinary team efforts to ease the process of incorporating imaging into patient care. Interdisciplinary teams should also be able to coordinate extensive clinical studies and the development of new radiotracers and AI applications.[115] By integrating these necessary multidisciplinary teams, we will be one step closer to reaping the full potential of molecular imaging in diagnosing and managing hepatocellular carcinoma, leading to worldwide benefits for patients.[116] Table 2 summarizes the main challenges and future directions in the molecular imaging of hepatocellular carcinoma.

Table 2: Challenges and Future Directions in Molecular Imaging for HCC

Challenges	Future Directions
Standardizing imaging protocols	Developing universally accepted protocols for consistency
Limited accessibility to advanced imaging technologies	Addressing equipment costs and infrastructure limitations
Lack of large-scale clinical validation studies	Conducting comprehensive studies for robustness and reliability
Need for novel radiotracers.	Developing radiotracers targeting emerging molecular markers
Integration of artificial intelligence	Advancing AI algorithms for refined diagnostic accuracy
Expanding theranostics in personalized medicine	Refining diagnostic and therapeutic integration for tailored treatments

Conclusion:

The nonstop progress of molecular imaging technologies has become pivotal in the ever-changing landscape of hepatocellular carcinoma (HCC) diagnosis and management. They represent a paradigm shift, providing a uniform increase in sensitivity and specificity for early disease detection and characterization of liver lesions with unprecedented precision. Integrating artificial intelligence (AI) and theranostics amplifies this transformational capacity, enabling the introduction of personalized and targeted treatment strategies in HCC. The applications of molecular imaging in hepatobiliary malignancies will be emphasized and understood better with the help of significant advances in the knowledge of molecular genetic characteristics and expression patterns associated with the progression of hepatobiliary malignancies both in experiments and in the rapidly developing field of genomics of human cancers. Merging molecular imaging with artificial emotion provides a newer approach to HCC control. Machine erudition algorithms evaluate molecular stage scenes and facilitate the analysis of molecular imagery with enhanced diagnostic ability and predictable comprehension. ‹The future integration of these advancements will lead to person-specific care emphasizing HCC value. It will use personalized medicine for HCC's unique features while designing treatment strategies for accuracy. Theranostics, which combines diagnosis and therapy in a single imaging agent, is the ultimate Expectation of Personalized Medicine in HCC. Identifying tumor-specific targets and then delivering treatment directly to the tumor is the promise of therapeutic imaging at both the gross and molecular genetics level, to focus these powerful therapies on tumor cells and spare collateral damage to healthy tissue, all to give the patient the best possible outcome and a dynamic, rather than static strategy for this mutable and many times, domiciled in a variety of genetic environments, disease. With the advent of molecular imaging and the advancements in hepatology research, each field is growing much more as a science. As in most instances, the more information provided to a doctor about the specifics, pathology, and size of the tumor, the better a doctor can treat the patient. Molecular imaging, in particular, can "untangle" HCC and provide diagnostic and descriptive imaging and functional imaging that can tell how the tumor is spreading, acting, and slowing the patient's body down.

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