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The Progress in Imaging Technologies and Implications for Nursing Practice: A Systematic Review

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Abstract

Background: The recent years have seen revolutionary advancements in medical imaging technologies, including artificial intelligence (AI), point-of-care ultrasound (POCUS), and hybrid imaging modalities like PET/MRI. These technologies have transformed diagnostic and therapeutic interventions. These technologies provide unprecedented functional and molecular information, with new implications for clinical care beyond traditional radiology. **Aim:** The aim of this review is to synthesize the literature from 2015 through 2025 to explore how these imaging technology advances are redefining nursing roles, responsibilities, and competencies. **Methods:** A Systematic literature review from 2015 through 2025 was conducted. The reviews were evaluated to assess the implications of the emerging imaging technologies for nursing practice within various clinical settings. **Results:** The outcome reflects a paradigm change for the nursing practice from a passive taker of imaging data to an active participant in the imaging cycle. Key implications are the increased responsibility in patient preparation for complex scans, intra-procedural surveillance, bedside data interpretation by POCUS, and the management of clinical alerts based on AI. Such development involves significant educational demands and ethical concerns of data privacy and accountability of algorithms. **Conclusion:** Advanced imaging technologies are irreversibly transforming nursing practice, demanding an innovative approach. To ensure patient safety and optimal outcomes, the profession must develop standardized curricula for education, foster robust interprofessional relationships, and establish explicit competency frameworks and policies to support nurses in this high-technology practice environment.

Keywords: nursing, medical imaging, artificial intelligence, point-of-care ultrasound, competency

1. Introduction

Medical imaging is a pillar of contemporary medicine, one that is essential to diagnosis, treatment planning, and assessment of the effectiveness of treatments. The recent decade, between 2015 and the current era, has seen an unprecedented rate of imaging technology innovation. This period is marked not by incremental advances but by paradigm shifts, revolutionizing how we image and comprehend human physiology and pathology (Zhang et al., 2021). The use of artificial intelligence (AI) for image reconstruction and analysis, the increased use of point-of-care ultrasound (POCUS) that is carried out by non-radiologists, the creation of better hybrid positron emission tomography/magnetic resonance imaging (PET/MRI) systems, and the availability of sensitive digital detectors as well as quantitative biomarkers are all feeding into a more precise, personalized, and data-based practice of medicine (Al Mohammad et al., 2024).

In this rapidly evolving world, the nurse's role is being dynamically redefined. Nursing practice,

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with its inherent focus on patient assessment, intervention, and teaching, overlaps with high-technology imaging in innovative and challenging fashions. Nurses are no longer just responsible for escorting patients to the radiology department or providing pre-procedure sedation; they are increasingly required to acquire knowledge of advanced imaging in a bid to provide safe and effective care (Shubayr, 2024). These include optimizing patients for scans with novel radiotracers, observing patients in MRI conditional devices, managing POCUS systems to answer specific clinical questions, and interpreting AI-generated alerts embedded in electronic health records.

This overview synthesizes current evidence and discusses implications of these new imaging technologies for nursing practice in various clinical specialties, including critical care, emergency departments, oncology, and perioperative services. It will delve into the implications of significant technology families to nursing—AI, POCUS, Hybrid Imaging, and Advanced MRI/CT—and the ensuing variations in workflows, patient care, and required competencies. Further, the overview will mention the ensuing educational requirements, ethics concerns, and implications for the future of the nursing profession. Through providing an integrated view, this paper endeavors to inform nursing curricula, guide clinical competency development, and encourage an engaged response toward more fully incorporating nurses into the high-technology imaging world of contemporary and future healthcare.

The Rise of Artificial Intelligence and Machine Learning in Imaging

Artificial intelligence, in its branch of machine learning (ML) and deep learning (DL), has evolved as the most transformative influence on medical imaging. AI algorithms can now perform tasks as basic as computer-assisted image reconstruction and noise reduction to complex lesion detection, segmentation, and disease classification (Li et al., 2023). For instance, AI algorithms can read chest X-rays for pneumonia, detect acute neurologic events on CT scans, and identify micro-metastases in oncologic imaging with an accuracy that is often equal to, and sometimes better than, that of their human equivalents (Van Nijnatten et al., 2023).

The nursing implications are indirect but transformative. As the radiologist's workflow is optimized, it can significantly reduce the time to critical findings. Computer vision-based and machine learning-based triage systems can mark life-threatening conditions such as pneumothorax, intracranial hemorrhage, or pulmonary embolism, and trigger instant notification to the clinical team (Obuchowicz et al., 2024). In this case, the nurse becomes the initial responder to an alert like this. This demands a higher degree of critical thinking: the nurse must rapidly absorb the data generated by the AI, correlate it with the clinical presentation of the patient, and initiate appropriate interventions or refer the case to higher care, but being cognizant of the limitations and potential for error of the AI algorithm (Pesapane et al., 2023). This is a departure from a reaction to a formal radiology report to reacting to a suspicion computationally generated.

Moreover, AI is optimizing risk prediction models that directly affect nursing surveillance. Models that review standard imaging for patient deterioration prediction, such as the identification of incipient respiratory failure on a chest X-ray or the forecasting of the risk of a fall from musculoskeletal status, are on the horizon (Hwang et al., 2021). Nurses will play a central role in applying these prediction results, transforming data into proactive, preventative nursing care plans. This merging requires digital health literacy, through which nurses must become familiar with interacting with AI-based clinical decision support systems that are merged into electronic health records (Lokmic-Tomkins et al., 2022).

Point-of-Care Ultrasound (POCUS): Involving the Nurse at the Bedside

Point-of-care ultrasound represents a paradigm shift in the practice of imaging, from moving away from the radiology department to the bedside of the patient. Characterized as ultrasound obtained and interpreted by the clinician at the time of care to answer a specific diagnostic question or aid in a procedure, POCUS has been widely adopted by emergency medicine and critical care physicians (Patel et al., 2021). Increasingly, its use by advanced practice providers as well as, in some environments, by registered nurses, is expanding the scope of nursing evaluation and intervention.

The nursing practice implications are simple yet important. In critical care settings, nurses with POCUS training can perform focused cardiac ultrasound to assess contractility and volume status, lung ultrasound to differentiate between the causes of acute respiratory failure (e.g., pulmonary edema versus pneumonia versus pneumothorax), and vascular ultrasound to aid in challenging intravenous access (Mongodi et al., 2022). This offers a real-time, non-invasive assessment that complements standard physical examination, leading to quicker diagnosis and improved individualized hemodynamic management (Rocca et al., 2023). For example, a nurse who gets B-lines on lung ultrasound in a patient presenting with dyspnea has tangible evidence of pulmonary edema on which to base right diuretic therapy.

Beyond critical care, POCUS is being utilized by wound care nurses to assess wound depth and undermining, nephrology nurses to assess residual bladder volume, and by palliative care nurses to guide symptom management (Thota et al., 2023). The ability to visualize internal structures and dynamics at the bedside supports clinical judgment, improves procedural success and safety, and enhances a more holistic, immediate approach to patient assessment.

However, this expansion brings with it significant challenges in the form of rigid, standardized training and credentialing to ensure competency and prevent misdiagnosis (Almotairi, 2024). The practice of nursing must therefore develop clear guidelines for POCUS training, scope of practice, and imaging documentation to ensure its safe and effective integration into regular nursing practice.

Hybrid and Molecular Imaging

Hybrid imaging scanners, such as PET/CT and recently PET/MRI, combine anatomical data with functional or metabolic information and provide an overall image of disease processes. These modalities have a central role in oncology for staging, restaging, and monitoring response to treatment, and also in neurology and cardiology (Zaidi & El Naqa, 2021). The creation of novel radiotracers distinct from the traditional fluorodeoxyglucose (FDG), targeting specific receptors, enzymes, or processes, is broadening the horizon of precision medicine (Al-Ibraheem et al., 2024).

For nurses, the creation of hybrid and molecular imaging implies increased complexity of patient preparation, monitoring, and post-procedure care. Preparing patients for a PET/MRI scan, for instance, is more complicated than for an individual. It requires meticulous attention to dietary restrictions, diabetic patient blood glucose regulation while they are undergoing scanning with FDG-PET, and detailed screening for MRI contraindications (e.g., certain implants, metal foreign bodies) as well as standard radiotracer precautions (Shubayr, 2024). The nurses are responsible for ensuring patient compliance with these precautions because any deviation will invalidate image quality and diagnostic accuracy.

Moreover, the scanning process itself is longer and can be more taxing for patients. Nurses are tasked with the management of patient anxiety, comfort, and monitoring of adverse effects, which, despite being rare, are potential with new radiotracers (Alqahtani, 2023). On the post-procedure side, patient education on radiation safety requires updated information, especially through the application of new isotopes with differing half-lives and excretion routes. Oncology nurses, in particular, must grasp the clinical significance of hybrid imaging results, such as SUV change on a PET scan, to engage in effective dialogue with patients about their disease and treatment trajectory (Nasiri et al., 2025). This deeper integration into the molecular imaging pipeline positions the nurse as gatekeeper, educator, and patient advocate during the age of personalized cancer care.

Advanced MRI and CT Technology

Conventional MRI and CT are excellent at providing exquisite anatomy, but new sequences and methods now provide quantitative microstructural and physiological information. MRI, DWI, DTI, MRS, and fMRI offer cellularity, integrity of white matter tracts, metabolic levels, and brain function information, respectively (Hanalioglu et al., 2024). Similarly, advanced uses of CT include perfusion imaging to assess blood flow within the tissues and dual-energy CT (DECT) for the detection of tissue content and the reduction of artifacts (McCollough et al., 2023).

The nursing implications are about specialty patient care and data interpretation in holistic care. For example, a patient who is undergoing an fMRI for brain mapping prior to surgery requires specialty nursing care. The patient must be instructed by the nurse to do some tasks (like moving a finger or remembering words) inside the noisy scanner, since cooperation is vital in the creation of genuine cortical maps (Sindhu et al., 2022). Nurses who treat stroke and traumatic brain injury patients in neurology units nowadays are confronted with DWI and perfusion maps. Having an understanding that a "mismatch" between these two sequences might identify tissue under risk of infarction (the penumbra) enables nurses to make greater sense of the imperative of intervention and monitor neurological alterations more perceptively (Hasan et al., 2018; Abdu Asiri et al., 2025).

In oncology, use of DWI in monitoring treatment response—where water diffusion enhancement is likely to indicate successful cell death—is a more nuanced measure of a patient's response than exclusive use of size-based RECIST criteria (Jackson et al., 2023). Such information allows nurses to provide more informed patient education and psychological counseling. Patient care being provided with contrast agents for these advanced studies also requires up-to-date information, including distinctions among iodinated (CT), gadolinium-based (MRI), and newer organ-specific contrast media and the corresponding protocols for screening and managing potential adverse effects (Güneş & Cesur, 2024).

Educational and Competency Implications for the Nursing Workforce

The extensive use of advanced imaging technology in the care of patients requires an immediate and ongoing need for innovation in nursing education and skills attainment. Traditional nursing curricula provide but a rudimentary overview of radiology, insufficient preparation for the realities described in this review (Abdul et al., 2022). Revision is in order, with imaging technology instruction integrated throughout undergraduate, graduate, and continuing professional education programs. Individual competencies have to be acquired in three domains: cognitive, psychomotor, and affective. Specific implications and required competencies for each of the key technology groups are listed in Table 1 and Figure 1.

Table 1: Key Advanced Imaging Technologies and Their Direct Implications for Nursing Practice

Technology	Core Advancement	Example Clinical Application	Specific Nursing Implications
Artificial Intelligence (AI)	Automated image analysis, pattern recognition, and predictive analytics.	Triage of head CTs for intracranial hemorrhage; detection of pulmonary nodules on chest X-rays.	- Responding to AI-generated critical finding alerts. - Understanding algorithm limitations to avoid over-reliance. - Integrating predictive analytics into nursing surveillance plans.
Point-of-Care Ultrasound (POCUS)	Bedside, clinician-performed imaging for real-time diagnosis and procedural guidance.	Lung ultrasound for dyspnea; focused cardiac ultrasound for shock; ultrasound-guided IV insertion.	- Performing and interpreting focused exams. - Expanding physical assessment skills. - Requiring formal training and credentialing for competency.
Hybrid Imaging (PET/MRI)	Fusion of metabolic (PET) and detailed soft-tissue (MRI) information in a single session.	Oncology staging; neurological disorder evaluation (e.g., dementia).	- Complex patient preparation (diet, glucose control, MRI safety). - Managing longer scan times and patient anxiety. - Educating patients on novel radiotracers and radiation safety.
Advanced MRI Sequences	Quantitative data on tissue microstructure, metabolism, and function.	fMRI for brain mapping; DWI for stroke and oncology; MRS for brain tumors.	- Providing specialized patient education and coaching during functional tasks in the scanner. - Understanding clinical significance of quantitative results (e.g., ADC values).
Dual-Energy CT (DECT)	Material decomposition to characterize tissue types and reduce artifacts.	Gout diagnosis (urate crystal detection); virtual non-contrast imaging; bone removal in angiography.	- Understanding expanded indications for CT. - Educating patients on the benefits of reduced need for multiple scans in some cases.

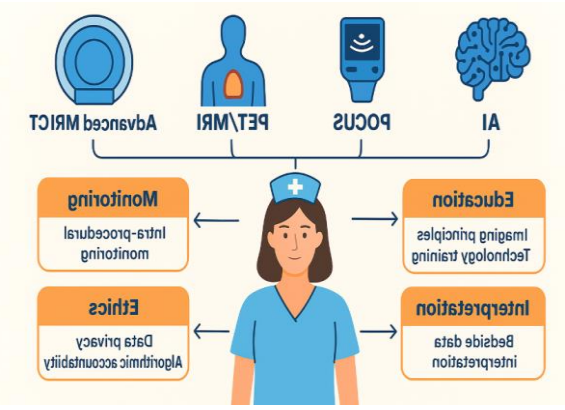

Figure 1: Integration of Advanced Imaging Technologies in Nursing Practice

Cognitively, nurses have to understand the underlying principles, indications, and limitations of key technologies like AI, POCUS, and hybrid imaging (Shubayr, 2024). They must be able to interpret AI-generated alerts and understand the clinical meaning of quantitative imaging biomarkers. Psychomotor skills are required for nurses practicing POCUS, with simulation-based hands-on training required to achieve proficiency in image acquisition and interpretation (Tian et al., 2024). Proficiency in safely managing patients with MRI-conditional devices (e.g., neurostimulators, insulin pumps) is required for all nurses. Affective competencies include facilitating comfort with technology, maintaining a patient-centered orientation in the high-technology environment, and working collaboratively with radiologists, sonographers, and information technology professionals (Al Mohammad et al., 2024). To make systematically feasible the meeting of these needs, a framework of core competencies must be employed, as illustrated in Table 2 and Figure 2.

Table 2: Proposed Core Competencies for Nurses Practicing during the Era of Advanced Imaging

Competency Domain	Specific Competencies	Example Educational Strategies
Cognitive/Knowledge	- Explain basic principles of AI, POCUS, MRI safety, and common radiotracers. - Describe the clinical indications and limitations of key advanced imaging tests. - Interpret common quantitative imaging biomarkers relevant to one's specialty (e.g., SUV in oncology).	- Integrated modules in nursing curricula. - Online continuing education modules. - Interprofessional grand rounds with radiology.
Psychomotor/Skills	- Safe operation of POCUS devices for designated applications. - Competent management of patients with MRI-conditional devices. - Ability to use PACS and EHR systems to view images and reports.	- Simulation-based training with manikins and standardized patients. - Supervised clinical practicums for POCUS. - Hands-on workshops for device management.
Affective/Professional	- Collaborate effectively with the interprofessional imaging team (radiologists, technologists). - Maintain a patient-centered approach while utilizing technology. - Demonstrate ethical practice regarding data privacy and AI-assisted decision-making. - Provide empathetic communication and support for patients experiencing "scanxiety."	- Interprofessional education (IPE) simulations. - Case-based discussions on ethics and communication. - Reflective practice exercises.

Figure 2: Core Nursing Competencies for Advanced Imaging Technologies

Interprofessional education (IPE) is an absolute instructional strategy. Educational sessions in which nursing students, medical students, and radiography technology students are combined can break down silos and engender the collaborative thinking essential for today's imaging-guided care (Abdul et al., 2022). Further, the development of certified postgraduate education and fellowships for nurses subspecializing in fields like critical care ultrasound or oncology imaging is a rational and necessary step to achieve expert-level competencies in the profession (Su et al., 2025).

Ethical, Legal, and Psychosocial Challenges

The extensive use of advanced imaging is followed by a plethora of ethical and legal challenges in which nurses are deeply involved. The "black box" nature of some complex AI algorithms raises questions of accountability. If an AI system misses a critical finding or a nurse reacts inappropriately to a faulty AI notification, who is ultimately held responsible—the developer, the hospital, the radiologist, or the nurse? (Pesapane et al., 2023). Sound governance frameworks and clinical guidelines should define the role of AI as a decision-support tool, not a replacement for clinical judgment, and clarify the roles of all healthcare professionals.

Privacy and data security are also the highest priority. Advanced imaging scans, especially hybrid and functional scans, are an example of highly sensitive biometric data. Nurses must be vigilant about maintaining confidentiality of this information and cognizant of regulations governing its use in practice and research (Alnaji & Alkhaldi, 2024). Furthermore, increased sensitivity of imaging may lead to the identification of "incidentalomas" or unexpected findings with indeterminate clinical significance. This can lead to a cascade of additional tests, biopsies, and much patient distress (Farjah et al., 2023). Nurses are frequently at the forefront of guiding patients through this uncertainty, and skills in communication, risk explanation, and psychological support are necessary.

From a psychosocial perspective, undergoing a lengthy, enclosed, or complex imaging process can be in itself a cause of significant distress. Nurses play a key role in deactivating this through therapeutic communication, patient teaching, and establishing a therapeutic atmosphere (Sindhu et al., 2022). As imaging continues to become a target of diagnosis and surveillance, nurses must also attend to the risk of "scanxiety"—anxiety specifically related to waiting

for and getting results, particularly in oncology (Angerilli et al., 2021).

Conclusion and Future Directions

The period 2015-2025 has reaffirmed that new imaging technologies are not stand-alone diagnosis tools but a part of the clinical care pathway. As outlined in this review, nursing implications are far-reaching, altering roles, responsibilities, and required competence. Nurses are emerging as technologically sophisticated practitioners who must deal with AI-produced notifications, employ bedside ultrasound, look after patients undergoing complex molecular imaging investigations, and interpret quantitative physiological data.

The future will bring even greater integration. Overlays of imaging information in the OR or with procedures with the help of augmented reality (AR) will require nurse-perioperative team coordination (Furman & Hsu, 2021). The field of radiomics that processes gigantic amounts of sub-visual information from images to predict tumor behavior or response to treatment will further augment the pool of data that has to be explained by nurses to their patients (Preuss et al., 2022). Portable low-field MRI scanners are emerging to find their place in intensive care units, bringing high-tech neuroimaging to the most vulnerable patients and calling for new critical care nursing skills (Sheth et al., 2021).

To deal with this technology-driven future successfully, the nursing profession must adopt an assertive and multifaceted approach. This is embarked upon with grassroots curriculum reform to integrate advanced imaging literacy and point-of-care ultrasound (POCUS) education into the core of nursing education so that graduating nurses possess the required competencies. Simultaneously, there is an urgent need for developing national and international competency models to standardize technology-related nursing competencies and ensure consistent, top-notch practice. It will be crucial to enhance interprofessional cooperation with radiology departments to facilitate mutual learning, establish common protocols, and break silos.

In addition, the profession must champion nursing-led research to create a robust evidence base for the impact of POCUS on patient outcomes, AI-nurse ergonomic collaboration, and evidence-based interventions for decreasing patient "scanxiety." Finally, nurses must achieve membership on hospital technology purchasing and implementation committees, having a critical voice to ensure the value of patient safety, clinically realistic workflows, and ethical integration of new imaging technologies into direct patient care. Overall, the advances in technology are a challenge and a great opportunity for the nursing profession. As nurses take these changes to heart, seek necessary education, and advocate for their integral role in the imaging continuum, they can guarantee that these powerful technological tools are used to create safer, more accurate, and more compassionate patient care.

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