The Evolution of Diagnostic Medical Sonography

Author's Name: Shweta Rathod

Prepared for: Haley Gibson

DMS 101 Foundations of Sonography

Canadian National Institute of Health

Date of Submission: February 22, 2025

Research Strategy Worksheet for EBDM Essay

1. Define your question using the following 'W5' format:
    a. What is the topic? : The Evalution of diagnostic medical sonography, including its advancement, future implications, and advantages and limitations-comparison with other imaging modalities.
    b. Who is affected; individual or groups? : Individuals as well as group is affected. Patients, sonographers, radiologists, emergency healthcare providers and medical researchers.
    c. Where, when and why does/can this happen? : Where: Hospitals, clinics, emergency rooms and rural healthcare settings. When: Sonography has progressed from the 1940s to the present and going to expand with advancement in AI and portable imaging solutions. Why: Ultrasound is radiation-free, cost effective and non-invasive imaging technic rising its demand for advancement in healthcare sector.
    d. What is the outcome and conclusion of your research analysis? : There is a significant progress and advancement in the field of medical diagnostic sonography with excellent image quality, portability and diagnostic capabilities compared to the past. The integration of AI, contrast-enhanced ultrasound-CEUS and new portable handy sonography devices will continue to improve its effectiveness and outcomes in future. Compared to CT and MRI, ultrasound is widely accessible, radiation free, non-invasive and cost effective, but it has limitations in resolution and penetration. Future innovation will solve some current present limitation of ultrasound, making it more vital in the field of medical diagnostics.

2. Instructor provided question/topic:

   How has medical diagnostic sonography been progressed today compared to past years?

   How and what will be the future impact of development in medical diagnostic sonography?

   How does it compare to other imaging modalities in terms of advantages and limitations?

3. List the main topics and terms from your topic/question that you can use to search:

   - Evaluation of sonography
   - Advancement in ultrasound technology
   - Doppler ultrasonography
   - 3D imaging
   - Contrast enhances ultrasound (CEUS)
   - Point of care ultrasound (POCUS)
   - Artificial intelligence (AI) in sonography
   - Comparision between sonography with CT and MRI
   - Advantages of sonography
   - Limitations of sonography

4. Check any limit that may pertain to your search:

   - Language: English
   - Year of publication: Preferred recent studies

5. Type of study/publication you want to include in your search:

   - Clinical Practice Guidelines
   - Journal of ultrasound in medicine

- Sonography Canada journal
- Individual Research Studies

6. Check the databases you searched:
   - Google Scholar
   - WebMD
7. What information did you find in your research to help answer your question?

   Historical development of sonography: Ultrasound has been used as a diagnostic tool for more than 40 years, starting from low resolution imaging limitation in past to the real time imaging with modern advances 3D images, high frequency transducers and doppler ultrasound shows its progressive evaluation throughout the years.

Szabo, T. L. (n.d.). *Diagnostic Ultrasound Imaging: Inside Out | ScienceDirect*. https://www.sciencedirect.com/book/9780123964878/diagnostic-ultrasound-imaging-inside-out

Troxclair, L., Smetherman, D., & Bluth, E. I. (2024). Shades of Gray: A History of the Development of Diagnostic Ultrasound in a Large Multispecialty Clinic. *The Ochsner Journal*, *11*(2), 151. https://pmc.ncbi.nlm.nih.gov/articles/PMC3119221/

Advancement in Technolgy: Modern 3D ultrasound technology provides more precise images that can help in diagnostic and treatment planning. Improvement in medical technologies have made sonography devices highly portable to be used smoothly at the point of care making sonography an essential tool in various medical fields worldwide.

Hussain, S., Mubeen, I., Ullah, N., Shah, S. S. U. D., Khan, B. A., Zahoor, M., Ullah, R., Khan, F. A., & Sultan, M. A. (2022). Modern Diagnostic Imaging Technique Applications and Risk Factors in the Medical Field: A Review. *BioMed Research International*, *2022*(5164970), 1–19. https://doi.org/10.1155/2022/5164970

Comparision with other imaging modalities: Ultrasound is efficacious, painless, portable and nonionizing method compared to CT and MRI. However, it has lower spatial resolution and limited penetration.

Features	**Ultrasound**	**Magnetic Resonance**	**Computed Tomography**
Radiation Exposure	None	None (Use strong magnetic field)	Use ionizing radiation
Cost	Affordable	Expensive	Moderate to high
Portability	High-Handheld portable devices available	Low	low
Imaging time	Fast	Slow	Fast
Best for imaging	Soft tissues, blood flow, real time imaging, fetal monitoring	Brain, spine, soft tissue, tumors, joints	Lungs, tumors, internal bleeding

Limitations	Limited penetration through bones and air, Operator dependent, Lower spatial resolution	Cannot used with metal implants, expensive with long scan time	Radiation exposure- not safe for pregnant women, allergic to contrast dye
Availability	Widely available in hospitals and clinics	Limited in rural area	Available in most hospital settings –requires high radiation safety

Bierig, S. M., & Jones, A. (2009). Accuracy and Cost Comparison of Ultrasound Versus Alternative Imaging Modalities, Including CT, MR, PET, and Angiography. *Journal of Diagnostic Medical Sonography*, *25*(3), 138–144. https://doi.org/10.1177/8756479309336240

Hussain, S., Mubeen, I., Ullah, N., Shah, S. S. U. D., Khan, B. A., Zahoor, M., Ullah, R., Khan, F. A., & Sultan, M. A. (2022). Modern Diagnostic Imaging Technique Applications and Risk Factors in the Medical Field: A Review. *BioMed Research International*, *2022*(5164970), 1–19. https://doi.org/10.1155/2022/5164970

Kremkau, F. W. (2015). *Sonography Principles and Instruments* - Elsevier Health Sciences.

Future Impact of Sonography:

The future of sonography will be shape by the new technologies such as contrast enhanced ultrasound (CEUS), Artificial intelligence (AI) and point of care ultrasound (POCUS). CEUS improve the detection of vascular abnormalities and tumor perfusion assessment.AI powered algorithms enhance image interpretations and reduce human errors and POCUS makes ultrasound more accessible particularly in emergency and rural areas. In future these modalities will play significant role in medical diagnostic sonography for successful clinical outcomes.

Avanzo, Michele, et al. "The Evolution of Artificial Intelligence in Medical Imaging: From Computer Science to Machine and Deep Learning." *Cancers*, vol. 16, no. 21, 1 Nov. 2024, pp. 3702–3702, www.mdpi.com/2072-6694/16/21/3702, https://doi.org/10.3390/cancers16213702.

Edwards, Christopher, et al. "The Application of Artificial Intelligence in the Sonography Profession: Professional and Educational Considerations." *Ultrasound*, vol. 30, no. 4, 21 Jan. 2022, p. 1742271X2110724, https://doi.org/10.1177/1742271x211072473.

Point-of-Care Ultrasound (POCUS) Certification Academy | *POCUS.org*. www.pocus.org/.

Xu, Hui-Xiong. "Contrast-Enhanced Ultrasound: The Evolving Applications." *World Journal of Radiology*, vol. 1, no. 1, 2009, p. 15, https://doi.org/10.4329/wjr.v1.i1.15

8. Essay reflecting on the research and analysis done to answer the question.

   The evolution of diagnostic medical sonography has vital role in healthcare system that enhance medical imaging by improving efficiency, accuracy and accessibility. Ultrasound field shows significant progress from low resolution static images to real time, high frequency and 3D imaging technics. Future advancement and innovation such as AI powered algorithms, CEUS and POCUS transform ultrasound into versatile, top tier

imaging modality. While ultrasound is radiation free, cost effective and portable, it has limitations in penetration, spatial resolution and operator dependance compared to CT and MRI. However, as researches progress ultrasound becomes essential part of diagnosis for next generation healthcare.

Diagnostic medical sonography has progressed impressively over the years, that enhance the accuracy and efficiency of medical imaging in the health sector. Sonographic imaging was initiated as a basic imaging modality, but it has now become a significant tool for diagnosing various abnormal pathological conditions in the human body. Moreover, it has gained popularity in clinics and hospitals because of easy visualization of soft tissues, organs and blood flow without any harmful ionizing radiation. This paper discusses the advancement in sonography, its future implications, and its comparative advantages and limitations relative to other medical imaging modalities.

The field of sonography has progressed significantly in terms of high resolution, portability and diagnostic capabilities. In the 1940s to 1950s, early ultrasound machines produced low-resolution images that had limited clinical utilities. By the 1970s, advancement in real time imaging allowed for the visualization of moving structures such as fetal development and the beating heart. Over time, drastic advancement in high frequency transducers, harmonic imaging and doppler ultrasonography have made it possible to visualize anatomical structures and hemodynamics with greater clarity. Additionally, modern 3D ultrasound technology enables the manipulation of images, providing more precise diagnostic and treatment planning. Furthermore, advancement in medical technology have made sonography devices highly portables, with some handheld ultrasound machines being small enough to be used in emergency settings.These devices provide rapid and life-saving diagnostic finding at the point of care, making sonography an essential tool in various medical fields including obstetrics, cardiology, musculoskeletal imaging and emergency medicine worldwide.

Advancement in medical imaging and artificial intelligence (AI) are shaping a new era of possibilities in the field of ultrasound .AI- based diagnostic imaging may, in the future, help speed up the interpretation of complex images and improve early diseases detection, beneficial for patients. AI powered algorithms are being developed to enhance diagnostic accuracy and reduce human errors, ultimately improving patient safety and treatment outcomes. Another promising advancement is CEUS –contrast enhanced ultrasound which uses microbubble contrast agents to improve vascular abnormality detection and tumor perfusion assessment. Additionally, POCUS-point of care ultrasound devices are becoming increasingly popular, allowing immediate bedside diagnostic and improving healthcare accessibility in remote and underserved populations.

Sonography offers several advantages over other imaging modalities, making it preferred choice in many clinical settings. Unlike computed tomography (CT) and X-Ray imaging, ultrasound is radiation free, making it much safer option, especially for pregnant women and pediatric patients. Additionally, ultrasound is also more cost effective than magnetic resonance imaging and CT scans, as it requires less infrastructure and lower operational costs. A key advantage of ultrasound is its portability with handheld devices enabling medical professionals to conduct imaging in emergency and rural setting where large CT or Xray machines are impractical. Furthermore, Ultrasound provides real-time imaging, which is essential for dynamic assessments, including guiding operative procedures and monitoring fetal movements. However, sonography has some limitation compared to CT and MRI. Ultrasound has lower spatial resolution making it less effective in detection of small lesions or deep-seated structures. Moreover, ultrasound has limited penetration through bones and air, making it difficult to image

the lungs and intestines. Unlike MRI, which provides high-contrast soft tissue imaging, ultrasound images can sometimes difficult to interpret, especially in obese patients or those with excessive bowel gas. Another major limitation is that image interpretation heavily depends on the operator's expertise leading to potential variability in diagnostic accuracy. Despite these challenges, ultrasound remains an essential tool in modern medicine particularly for obstetrics evaluations and vascular assessments.

Medical diagnostic sonography has undergone significant advancements, making it a cornerstone of medical imaging due to its noninvasive, radiation free and real time imaging capabilities. In future, these advancements are more improved with AI integrations and portable imaging solutions, will further enhance diagnostic precision and accessibility. However, compared to other imaging modalities it has limitations in penetrating deep tissues and dependency on operator expertise, which highlights area for continue research- innovation. Despite these challenges, sonography continues to in provide safe, effective and efficient imaging solution, making it indispensable tool for diagnosing a wide range of medical conditions.

References

Avanzo, M., Stancanello, J., Pirrone, G., Drigo, A., & Retico, A. (2024). The Evolution of Artificial Intelligence in Medical Imaging: From Computer Science to Machine and Deep Learning. *Cancers*, *16*(21), 3702–3702. https://doi.org/10.3390/cancers16213702

Bierig, S. M., & Jones, A. (2009). Accuracy and Cost Comparison of Ultrasound Versus Alternative Imaging Modalities, Including CT, MR, PET, and Angiography. *Journal of Diagnostic Medical Sonography*, *25*(3), 138–144. https://doi.org/10.1177/8756479309336240

Edwards, C., Chamunyonga, C., Searle, B., & Reddan, T. (2022). The application of artificial intelligence in the sonography profession: Professional and educational considerations. *Ultrasound*, *30*(4), 1742271X2110724. https://doi.org/10.1177/1742271x211072473

Hussain, S., Mubeen, I., Ullah, N., Shah, S. S. U. D., Khan, B. A., Zahoor, M., Ullah, R., Khan, F. A., & Sultan, M. A. (2022). Modern Diagnostic Imaging Technique Applications and Risk Factors in the Medical Field: A Review. *BioMed Research International*, *2022*(5164970), 1–19. https://doi.org/10.1155/2022/5164970

Kremkau, F. W. (2015). *Sonography Principles and Instruments - E-Book*. Saunders.

Point-of-Care Ultrasound (POCUS) Certification Academy | POCUS.org. (n.d.). https://www.pocus.org/

Szabo, T. L. (n.d.). *Diagnostic Ultrasound Imaging: Inside Out | ScienceDirect*. https://www.sciencedirect.com/book/9780123964878/diagnostic-ultrasound-imaging-inside-out

Troxclair, L., Smetherman, D., & Bluth, E. I. (2024). Shades of Gray: A History of the Development of Diagnostic Ultrasound in a Large Multispecialty Clinic. *The Ochsner Journal*, *11*(2), 151. https://pmc.ncbi.nlm.nih.gov/articles/PMC3119221/

Xu, H.-X. (2009). Contrast-enhanced ultrasound: The evolving applications. *World Journal of Radiology*, *1*(1), 15. https://doi.org/10.4329/wjr.v1.i1.15