

Pediatric Interventional Cardiology Arm Positioning Device

The Effect of Artificial Intelligence Implementation in Catheterization Laboratories

A Thesis Prospectus
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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction:

Artificial intelligence is an emerging technology that has infiltrated almost every industry of work, causing a major shift to both professional landscapes and the technical skills needed to excel in one's field. Specifically within a clinical setting, artificial intelligence has produced promising results in preliminary testing and implementation for diagnostic purposes. In diagnostic radiology, highly trained board-certified medical professionals analyze images from a variety of imaging techniques and viewpoints in order to either diagnose or assess the severity of many medical conditions. This step of processing has previously could not be completed using traditional statistical methods due to the high number of inputs produced from images and videos. With recent developments in artificial intelligence, however, studies that have taken place are beginning to reveal this new technology as a promising alternative for image processing (Lim et al., 2020).

In every clinical scenario, considerations for responsibility and ethics are of high importance when determining a treatment plan. There are conflicting principles when applying ethics to medical treatment, as different ethical philosophies can advocate for unique actions to take in any scenario. Care ethics describes the significance of the fundamentals of dependencies in any relationship (*Care Ethics* | *Internet Encyclopedia of Philosophy*, n.d.). In medicine, this could refer to the dependencies of patients on healthcare professionals and the importance for physicians to act in the best interest of a vulnerable patient. This form of ethics differs from utilitarianism in the way in which it specifically derives context and rationalism from the situation in question (Maio, 2018). Both philosophies can be used to justify different outcomes in healthcare, but is important to consider multiple perspectives when making an informed ethical decision.

Technical Project:

My technical project focuses on the limitations of medical device equipment available for pediatric patients. Working alongside a team of peers and pediatric cardiologist, Dr. Michael Shorofsky, we plan to design and build a device that allows a pediatric patient's arms to be lifted up and away from their abdomen during a cardiac catheterization procedure. In these procedures, it is important that the patient's arms are not obstructing the view of the abdomen for both the lateral and vertical X-rays that indicate the catheter position during the procedure. There is currently no device on the market for this repositioning that is designed for pediatric patients. This can cause stress and burden for doctors, nurses, and anesthesiologists, as materials such as towels and foam must be used throughout the procedure to hold the patient's arms in place. This method of repositioning and lack of standardization can leave the patient at risk of brachial plexus injuries if their arms are not secured correctly throughout the entire procedure (Souza Neto et al., 1998).

There are a variety of factors that my team and I set out to consider before beginning the design process for our device. We first observed a pediatric cardiac catheterization to see, first hand, the issues with the current device and the current alternative method that is used. In this process, we witnessed the lack of standardization in the method for arm positioning. Our goal is to create a device that is both safe and effective for patients and doctors, allowing a more standardized way to position pediatric patients under anesthesia.

One important consideration of the design process includes the choice of materials used for the device. In a procedure in which an X-ray is continuously used, it is important to use only devices with no material radiation absorption (*Radiation Resistant Plastics* | Ensinger, n.d.). Additionally, because one of our specific aims for the device is the versatility of use in ages

ranging from 0 to 21 years, our device must be adjustable in both height and length while still holding a rigid shape to prevent any unnecessary movement during the procedure.

Diagnostic Radiology:

There are multiple different methods currently used by radiologists to diagnose different ailments depending on the severity and placement in the body. One commonly used method in cardiology is echocardiography, which involves the use of ultrasound waves to determine the functionality of the heart. This method can be used to diagnose a variety of different conditions affecting the heart, including cardiomyopathy, cardiac amyloidosis, pulmonary arterial hypertension, and patent ductus arteriosus. Each of these conditions can vary in terms of severity and require a well trained medical professional to assess the images and videos produced from the echocardiogram. In a cardiac cath lab, echocardiography is used in order to determine the correct placement of a catheter in the procedure. Additionally, images and videos are often taken during a cardiac catheterization procedure in order to assess blood flow direction and amount (*Cardiac Catheterization - Mayo Clinic*, n.d.).

My research question is centered around this technology and its potential for an integration with AI: How can advancements in applications within a clinical setting affect catheterization laboratories and what ethical considerations should be taken into account? The first method I will deploy to collect research will involve the analysis of similar studies that have been conducted in the past, both relating to artificial intelligence use for X-ray diagnosis, as well as specific studies conducted on catheterization laboratories. This will be effective in gathering the context for this new technology and the current implications it has in the present. Additionally, my research will aid in the question formation process necessary to prepare for my second method of research, including interviews with healthcare professionals.

The Effect of Artificial Intelligence on the Field of Radiology:

There is a combination of excitement and concern for the effect of artificial intelligence advancements on the field of radiology. The prospect of having an analysis technique that is both cheaper to implement and more accurate would bring benefit to both hospitals and patients. It is important to consider, however, the value that this new technology would need to bring in order to justify potential job displacement for the radiologists and echocardiographers who are currently tasked with this analysis. Although job replacement is prevalent across many industries due to advancements in artificial intelligence, it is important to consider a cost-benefit analysis specifically in healthcare.

In a cardiac cath lab, the conditions that are diagnosed and treated can range in levels of severity, from routine to high risk. When implementing artificial intelligence into other industries, such as tech, there is not often a consideration for the risk that a faulty algorithm would pose on the individual that the product is marketed towards. In medicine however, a deep learning model that has been improperly trained or that delivers incorrect results could be life threatening. In order to justify the widespread implementation of these models in echocardiography, it is important that sufficient testing and cross checking is performed to verify any results.

Additionally, one complication that the use of artificial intelligence could pose is the designation of responsibility for the results. In a traditional use of radiology for diagnosis, the radiologist will be held accountable for any diagnosis made according to the images or videos produced from the equipment. Usually a doctor caring for any patient must take accountability for any effects, either negative or positive, that are observed as a result of the chosen plan of treatment. With AI diagnostics, however, this accountability factor becomes more convoluted.

Framework:

One form of ethics that is used in a medical setting in order to make informed decisions for a patient is the ethics of care. This philosophy focuses on highlighting both sides of an ethical problem, as opposed to viewing anything as one-sided (Maio, 2018). This, by nature, allows a more flexible approach to determining the ethical route in a medical situation, but also creates more nuances without the ability to strictly follow a specific principle. It is described as an ethical approach with multiple perspectives: that of the person giving care and of the person receiving it. Additionally, it highlights the importance of prioritizing both friendship and reciprocity in these scenarios.

Another form of ethics that is taken into account in medicine is utilitarianism. In this ethical principle, the end of a situation must justify any means taken to reach that end result. Throughout the situation, the greatest overall benefit must be derived from the decision taken and must benefit the greatest number of individuals (Chukwuneke & Ezenwugo, 2022). In a medical context, this would require a physician to make a decision for a patient that will produce the greatest benefit for both the patient and other individuals involved. This could range from choosing a successful treatment plan that a patient agrees on to making a split-second decision to save a patient's life in an emergency triage situation.

In the context of diagnostic radiology, these ethical considerations could lead to different conclusions drawn about the implementation of artificial intelligence. When considering the ethics of care, it could be argued that there is not enough benefit to the patient side of the diagnostic process in order to justify the disruption that an artificial intelligence model could have on the job security of radiologists. In order to justify this change in standardized treatment, the technology being implemented must be significantly more sophisticated and accurate than

what a radiologist is able to provide. There is the potential for this technology to allow for a second opinion and greater accuracy both in the diagnostic and peer review process, rather than replacing radiologists altogether, maximizing the benefit to both healthcare professionals and patients in a utilitarianism lens. This depends, however, on the extent to which artificial intelligence can or should be implemented in the treatment process. A deep learning algorithm used to interpret a scan could be considered an aid to a radiologist, but a program that can process, diagnose, and draft a report of the findings as a doctor might do would have a much greater disruption to the field (*Will AI Replace Radiologists, or Just Make Them Better Than Ever?* | *MedPage Today*, n.d.).

Research Question and Methods:

Throughout both the process of completing my technical project and my STS project, I will have access to a pediatric catheterization laboratory and medical staff working in the lab. I plan to utilize these resources by conducting interviews with a variety of Doctors, nurses, anesthesiologists, and radiologists in order to gain a better understanding of how AI is currently deployed in the UVA hospital with the technology and resources available. I will conduct these interviews following my initial contextual research on the current state of the technology through scientific literature and articles. Because this technology, in combination with diagnostic radiology technology, can be extremely expensive, it will be beneficial to understand the level of funding and research needed to combine the two, and if UVA is currently allocating their resources into this opportunity (Beyar et al., 2021).

I plan to conduct this research beginning at the end of the fall semester and plan to complete my research by the end of February. More specifically, I will complete my research of key texts, including both the context for my research topic and the ethical framework lens in

which I am tackling the problem, over the winter break and before the start of the spring semester. Once I fully understand this background information necessary to construct thoughtful and targeted questions, I will begin to conduct interviews with employees within the UVA health system, with an emphasis on health care professionals working in catheterization laboratories or radiology. I plan to schedule these interviews over the course of one to two months, beginning at the start of the spring semester until the end of February 2025.

Key Texts:

- Chu, L. C., Anandkumar, A., Shin, H. C., & Fishman, E. K. (2020). The Potential Dangers of Artificial Intelligence for Radiology and Radiologists. *Journal of the American College of Radiology*, 17(10), 1309–1311. <https://doi.org/10.1016/j.jacr.2020.04.010>^{[L][SEP]} This source discusses the potential dangers of the use of artificial intelligence in the field of radiology. More specifically, it highlights the potential for physicians to become overly reliant on a technology that has the potential to produce biased results. This source will be helpful for my paper to highlight the risks of AI and whether or not the benefits outweigh them from an ethical standpoint.^{[L][SEP]}
- Chukwuneke, F. N., & Ezenwugo, A. C. (2022). Deontology vs. Utilitarianism: Understanding the Basis for the Moral Theories in Medicine. *International Journal of Medicine and Health Development*, 27(1), 19. https://doi.org/10.4103/ijmh.IJMH_57_20^{[L][SEP]} This source helps to break down the difference in the ethical principles, deontology and utilitarianism, in the context of a medical setting. Specifically, it highlights the patient focus in deontology and the society focus in utilitarianism. Although I am focusing on just utilitarianism and care ethics, this source is helpful to gather specific information about utilitarianism in a comparing and contrasting format.^{[L][SEP]}
- Lim, L. J., Tison, G. H., & Delling, F. N. (2020). Artificial Intelligence in Cardiovascular Imaging. *Methodist DeBakey Cardiovascular Journal*, 16(2), 138–145. <https://doi.org/10.14797/mdcj-16-2-138>^{[L][SEP]} This source discusses the potential for wide implementation of AI in the field of Cardiovascular imaging. From a benefits and risks standpoint, the piece mainly highlights the potential benefits, including the elimination of human error and a more efficient clinical workflow. This source is important for me to understand the potential benefits of this technology.^{[L][SEP]}
- Mol, A. (2008). *The Logic of Care: Health and the Problem of Patient Choice*. Routledge.^{[L][SEP]} This source highlights the current state of healthcare and discusses some of the methods to improve patient care overall through collaboration and technological advancement. It looks at healthcare through a lens of care ethics, so it will be helpful for me to better understand the framework that I am using to tackle my research question.^{[L][SEP]}

Moore, H. L. F. 26-]. (2000). *The Adjudication of Utilitarianism and Rights in the Sphere of Health Care* (Law Stacks). P. Lang.^[1]_{SEP} This source looks deeply into the current state of healthcare through a utilitarianism lens, specifically highlighting patient rights. This source will be helpful for me to compare and contrast utilitarianism with care ethics and highlight the major differences in the philosophies that are relevant to the advancements in AI in diagnostic radiology.^[1]_{SEP}

Sources:

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- Cardiac catheterization—Mayo Clinic*. (n.d.). Retrieved October 15, 2024, from <https://www.mayoclinic.org/tests-procedures/cardiac-catheterization/about/pac-20384695>
- Care Ethics | Internet Encyclopedia of Philosophy*. (n.d.). Retrieved October 15, 2024, from <https://iep.utm.edu/care-ethics/>
- Chu, L. C., Anandkumar, A., Shin, H. C., & Fishman, E. K. (2020). The Potential Dangers of Artificial Intelligence for Radiology and Radiologists. *Journal of the American College of Radiology*, 17(10), 1309–1311. <https://doi.org/10.1016/j.jacr.2020.04.010>
- Chukwuneke, F. N., & Ezenwugo, A. C. (2022). Deontology vs. Utilitarianism: Understanding the Basis for the Moral Theories in Medicine. *International Journal of Medicine and Health Development*, 27(1), 19. https://doi.org/10.4103/ijmh.IJMH_57_20
- Lim, L. J., Tison, G. H., & Delling, F. N. (2020). Artificial Intelligence in Cardiovascular Imaging. *Methodist DeBakey Cardiovascular Journal*, 16(2), 138–145. <https://doi.org/10.14797/mdcj-16-2-138>
- Maio, G. (2018). Fundamentals of an Ethics of Care. In F. Krause & J. Boldt (Eds.), *Care in Healthcare: Reflections on Theory and Practice*. Palgrave Macmillan. <http://www.ncbi.nlm.nih.gov/books/NBK543745/>
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