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RESEARCH ARTICLE

SAFE AND STRATEGIC: PRE-PROCEDURE INTERVENTIONAL HARDWARE PLANNING FOR RADIATION PROTECTION OF PATIENTS AND PRACTITIONERS

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ABSTRACT

Interventional radiology (IR) utilizes minimally invasive techniques guided by imaging technologies to diagnose and treat various conditions within the body. This study explores the benefits of pre-planned hardware strategies in IR procedures, aiming to optimize procedural efficiency while minimizing radiation exposure. Methods include stratified sampling, imaging modalities, statistical analysis, computational modeling, and clinical observations to study arterial anatomy variations. A prospective study design involved comprehensive patient evaluation and collaboration among interventional radiologists to formulate detailed plans for intervention hardware tailored to each patient's vascular anatomy. Implementation of pre-planned hardware strategies resulted in improved procedural efficiency, reduced radiation exposure, and enhanced patient outcomes. Future research should focus on long-term implications and broader implementation of this approach.

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INTRODUCTION

Interventional radiology (IR) is a medical specialty that uses minimally invasive techniques, guided by imaging technologies such as X-rays, CT scans, or ultrasound, to diagnose and treat a wide range of conditions inside the body. It involves the use of needles, catheters, and other small instruments to perform procedures such as angioplasty, embolization, biopsies, and stent placements, among others. Interventional radiology offers many advantages over traditional surgery, including shorter recovery times, less pain, and lower risk of complications. Ingoing radiation" typically refers to the radiation that is directed towards a specific target or area. This term is commonly used in various fields, including radiation therapy and interventional radiology. In radiation therapy, ingoing radiation refers to the radiation beams aimed at a tumor or specific region of the body to treat cancerous cells. In interventional radiology, it may refer to the radiation used during procedures such as angiography or fluoroscopy, where X-rays are directed towards the area of interest to guide the placement of catheters, stents, or other interventions. In both contexts, ingoing radiation is carefully controlled and monitored to ensure effective treatment while minimizing exposure to surrounding healthy tissues. Interventional equipment refers to a wide range of medical devices and instruments used in interventional procedures to diagnose and treat various conditions. Some common examples of interventional equipment include:

- **Catheters:** Flexible tubes inserted into blood vessels or other body cavities to deliver medications, perform angioplasty, embolization, or to collect samples for biopsy.
- **Guidewires:** Thin, flexible wires used to navigate through blood vessels or other anatomical structures to guide the placement of catheters and other devices.
- **Balloons:** Inflatable devices used in angioplasty procedures to open narrowed or blocked blood vessels.
- Stents: Metal or plastic tubes inserted into blood vessels or other ducts to help keep them open and improve blood flow.
- **Embolization materials:** Small particles, coils, or gels injected into blood vessels to block blood flow to tumors or abnormal blood vessels.
- **Imaging equipment:** X-ray machines, fluoroscopy units, ultrasound machines, and CT scanners used to visualize the inside of the body and guide the placement of interventional devices
- **Surgical tools:** Various instruments such as forceps, scissors, and retractors used to manipulate tissues during interventional procedures.

These are just a few examples of the diverse range of equipment used in interventional medicine, which continues to evolve with advancements in technology and medical techniques.

METHODS AND MATERIALS

Interventional radiology procedures demand meticulous planning to ensure both efficacy and safety for patients and practitioners. Traditional practices often involve ad hoc adjustments to intervention hardware during procedures, leading to prolonged radiation exposure and potential risks. This note explores the benefits of a study design focusing on pre-planned hardware strategies in interventional radiology, aiming to optimize procedural efficiency while minimizing radiation exposure to accommodate the variations in arterial anatomy and the diversity in patient height and weight, a study can be conducted using a combination of the following methods

- **Stratified Sampling:** Divide the study population into subgroups based on age, gender, body mass index (BMI), and other relevant factors to ensure representation across different demographics. This approach allows for a more accurate assessment of how arterial anatomy varies within specific population segments.
- **Imaging Modalities:** Utilize various imaging techniques such as CT angiography, magnetic resonance angiography (MRA), or ultrasound to capture detailed images of arterial structures in different individuals. These imaging modalities can help identify variations in arterial anatomy, including tortuosity, calcification, and other anomalies.
- **Statistical Analysis:** Analyze the collected data using statistical methods to identify trends and patterns in arterial anatomy across the study population. This may involve calculating averages, standard deviations, and other descriptive statistics to characterize the variability in arterial morphology.
- **Computational Modeling:** Develop computational models based on the collected imaging data to simulate arterial anatomy variations in virtual patient populations. These models can account for differences in height, weight, and anatomical characteristics to provide insights into how these factors impact procedural outcomes.
- **Clinical Observations:** Supplement imaging data with clinical observations from interventional procedures performed on patients with diverse arterial anatomies. This qualitative information can provide valuable insights into the practical implications of different arterial configurations on procedural success and patient outcomes.

By employing these methods, researchers can effectively study arterial anatomy variations and their implications for interventional procedures while accounting for differences in patient demographics such as height, weight, and anatomical characteristics.

Study Design: In interventional radiology, procedures often commence without pre-planned intervention hardware, relying instead on ad hoc adjustments based on real-time patient evaluation and pathological/radiological reports. While this approach offers flexibility, it can lead to increased radiation exposure for both patients and practitioners. Physicians may need to modify basic hardware like sheaths and catheters mid-procedure, inadvertently prolonging radiation exposure. To mitigate this risk, there's a growing imperative for streamlined hardware planning strategies to minimize unnecessary radiation while maintaining procedural adaptability. In this prospective study, patients scheduled for interventional radiology procedures were carefully selected based on predefined inclusion criteria, including the type of procedure required and the complexity of the patient's condition. Upon arrival at the intervention lab, patients underwent a comprehensive evaluation, including a review of their pathological and radiological reports and scans. Interventional radiologists collaborated to formulate a detailed plan for the diagnostic or therapeutic procedure, incorporating precise specifications for intervention hardware tailored to each patient's arterial anatomy. The pre-planning process encompassed considerations such as the selection of the access side, the choice of appropriate hardware (including sheaths, catheters, micro-catheters), catheter shape and size, balloon size, embolization materials, and coil specifications. These decisions were informed by the patient's current scan data, ensuring a customized approach to hardware selection optimized for the patient's unique vascular anatomy and procedural requirements.

Study site and data Gathered: Ethical Considerations: Ethical approval for the study was obtained from the Scientific and Medical Research Committee of OPJS University, Churu, Rajasthan. All aspects of the study, including patient recruitment, data collection, and informed consent procedures, were conducted in accordance with ethical guidelines and regulations. By conducting the study at both government and private hospitals, the research aimed to capture a comprehensive understanding of interventional radiology practices and outcomes across different healthcare settings, contributing to the advancement of knowledge in the field of radiology and imaging technology. The study was conducted at multiple sites, including a government hospital and several private multi-specialty hospitals, located in AIIMS Patna. These sites were chosen to ensure a diverse patient population and access to a range of interventional radiology procedures.

RESULTS

The implementation of pre-planned hardware strategies resulted in notable improvements in procedural efficiency and radiation safety. By having intervention hardware selected prior to the procedure, unnecessary delays and adjustments during the intervention were minimized. Physicians could proceed with greater confidence, knowing that the chosen hardware was specifically tailored to the patient's arterial anatomy, reducing the need for mid-procedural changes and associated radiation exposure. Furthermore, the systematic approach to hardware planning facilitated smoother procedural workflows, enhancing overall efficiency in the intervention lab. Physicians reported a reduction in procedural times and improved patient outcomes, attributed in part to the optimized selection of intervention hardware based on pre-procedural planning.

DISCUSSION

The findings from this study underscore the importance of proactive hardware planning in interventional radiology procedures. By integrating patient-specific data and leveraging advanced imaging technologies, interventional radiologists can develop comprehensive plans for intervention hardware, minimizing the need for ad hoc adjustments and reducing radiation exposure for both patients and practitioners.

Future Directions: Further research is warranted to explore the long-term implications of pre-planned hardware strategies in interventional radiology. Additionally, studies evaluating the cost-effectiveness and scalability of this approach across different healthcare settings could provide valuable insights into its broader implementation and impact on clinical practice.

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