



Advancements in Cardiac Catheterization Safety: Novel Radiation Protection Approaches Redefining Occupational Health



Zahra Shaghghi¹, Roozbeh Narimani Javid² and Maryam Alvandi^{3,4,*}

¹Cancer Research Center, Institute of Cancer, Avicenna Health Research Institute, Hamadan University of Medical Sciences, Hamadan, Iran; ²Student Research Committee, Hamadan University of Medical Sciences, Hamadan, Iran; ³Cardiovascular Research Center, Hamadan University of Medical Sciences, Hamadan, Iran; ⁴Department of Nuclear Medicine and Molecular Imaging, School of Medicine, Hamadan University of Medical Sciences, Hamadan, Iran

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Abstract: Radiation exposure poses a substantial occupational risk for healthcare professionals in the catheterization laboratory (cath lab). The escalating complexity and frequency of interventional procedures, such as cardiac catheterizations and percutaneous coronary interventions, underscore the need for innovative strategies to mitigate radiation exposure. While traditional measures like lead aprons, thyroid collars, and goggles have been pivotal in reducing radiation exposure, they have limitations, especially during prolonged and intricate procedures. Consequently, there is a growing demand for advanced radiation protection methods that prioritize safety without compromising procedural efficacy. Recent strides in radiation protection technology have given rise to novel shielding devices and zero-radiation approaches tailored for cath lab use. The novel shields leverage innovative materials and designs to achieve superior attenuation of both scattered and direct radiation. Their ergonomic and adjustable features also ensure optimal shielding coverage without impeding the operator's skill or workflow. Multiple studies have validated the effectiveness of these advanced radiation protection methods in diminishing occupational radiation exposure in the cath lab. Initial findings suggest a significant reduction in doses for operators and staff, potentially lowering the risk of radiation-induced health complications over the long term. This article provides a comprehensive review of the current landscape of radiation protection shields in the cath lab, emphasizing the efficacy and potential of these cutting-edge shielding technologies.

Keywords: Radiation, cardiac catheterization, ionizing radiation, 3D-electroanatomic mapping, fluoroscopy, multimodal imaging.

1. INTRODUCTION

Interventional cardiologists and electrophysiologists exposed to prolonged radiation exposure in catheterization laboratories (Cath lab) face the highest cumulative radiation levels among healthcare professionals [1]. The dose of radiation exposure differs significantly among various interventional procedures. Structural or valvular cardiac procedures are the most radiation-intensive procedures, followed by peripheral vascular procedures [2]. In the context of electrophysiology procedures, the utilization of 3D-electroanatomic mapping (EAM) and multimodal imaging has allowed operators to minimize the need for fluoroscopy, thereby reducing radiation exposure [3]. The use of ionizing radiation in cardiac catheterization procedures has raised concerns regarding its impact on both patients and medical personnel [1, 4].

Ionizing radiation can lead to stochastic and deterministic effects on human tissues [5, 6]. Deterministic effects, such as cataracts, exhibit escalating severity with higher doses due to a discernible threshold. In contrast, stochastic effects like cancer risk are thought to increase linearly without a specified threshold [7].

The International Commission on Radiological Protection (ICRP) sets recommended dose limits for occupationally exposed workers in medical interventional procedures. These limits include a maximum whole-body effective dose of 20 msv/year and specific limits for hands, feet, skin, and eye lenses [8]. Addressing this issue, there is a growing emphasis on minimizing radiation exposure through various steps. The ALARA (As Low as Reasonably Achievable) principle guides physicians to optimize radiation protection, emphasizing the need to reduce health risks using current knowledge.

Three conventional key measures include reducing exposure duration, increasing distance from the radiation source,

*Address correspondence to this author at the Cardiovascular Research Center, Hamadan University of Medical Sciences, Hamadan, Iran; E-mail: maryamalvandi@yahoo.com

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LIST OF ABBREVIATIONS

APD	=	Active Personal Dosimeters
CRT	=	Cardiac Resynchronization Therapy
CTO	=	Chronic Total Occlusions
EAM	=	3D-electroanatomic mapping
ICE	=	Intracardiac Echocardiography
ICRP	=	International Commission on Radiological Protection
LV	=	Left Ventricular
PPE	=	Protective Equipment
RMN	=	Remote Magnetic Navigation
RPCs	=	Radiation Protection Cabins
RSS	=	Radiation Shielding System
XRBS	=	X-ray Blankets
ZG	=	Zero-Gravity

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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