Cardiology & Cardiovascular Research

Research Article

Radiation Exposure in Mobile Catheterization Laboratory from 2008 is Over Two Times Higher Compared to Fixed Catheterization Laboratory from 2016

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ABSTRACT

Background: Mobile catheterization laboratories offer a relatively rapid equipment option for hospitals with the potential benefit to maintain patient access of needed percutaneous procedures. One concern is the Xray equipment may not be contemporary, resulting in higher radiation exposure to staff and patients. The aim of the study was to compare radiation exposure with procedures performed in a mobile versus a fixed catheterization laboratory.

Methods: Absorbed dose measured in milligray (mGy) was measured from the Xray equipment in the mobile lab (manufactured in 2008) and the fixed laboratory (manufactured in 2016). The effective dose measured in millisievert (mSv) was measured after each case from dosimeters worn by the operators. A total of 61 cases were reviewed, 30 in the mobile and 31 in the fixed laboratory. Data were collected from each case, including mGy, mSv, number of frames, fluoroscopy time, type of procedure, vascular access location, horizontal radiation absorbing pads (HRAP), body mass index (BMI) and contrast volume.

Results: There were no significant differences in BMI, access site, number of HRAP, contrast volume, frames per case and fluoroscopy time. The mobile lab measured mGy greater than 2.7 times higher ($p<0.005$) and the mSv was great than 2 times higher ($p<0.05$) versus the fixed catheterization laboratory.

Conclusions: While mobile catheterization laboratories provide maintenance of percutaneous procedures for hospitals, they may have older Xray equipment, which can result in over two times the radiation exposure to both patients and staff.

Keywords

Mobile catheterization laboratories, Xray, Radiation Exposure.

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Received: Jun 18, 2024; **Accepted:** Aug 02, 2024; **Published:** Aug 10, 2024

Citation: Panetta CJ, Galbraith EM, Yanavitski M, et al. Radiation Exposure in Mobile Catheterization Laboratory from 2008 is Over Two Times Higher Compared to Fixed Catheterization Laboratory from 2016. Cardiol Cardiovasc Res. 2024; 2(2):1-3.

Introduction

The use of mobile catheterization laboratories (Figure 1) provides a quick option for hospitals [1-3] with a potential benefit of reducing disparities in access to cardiac catheterization in underserved groups like those in rural areas without fixed hospital-based laboratories [3]. The rapid delivery and function of these portable laboratories allow hospitals to easily maintain access to interventional procedures. One caveat is that some of these portable laboratories have equipment that is not contemporary, raising the potential for higher radiation exposure to staff and patients [4,5]. Comparative data for radiation burden with mobile versus fixed catheterization laboratories are not available. We examined radiation in both a mobile and a fixed catheterization laboratory, using both the absorbed dose and the effective dose, and compared factors that may impact radiation levels, including type of cardiac catheterization procedure and patient size.

Figure 1: Mobile catheterization laboratory interior without accessory equipment such as sterile table, medication cabinet, code blue crash cart, equipment cabinets and contrast injector.

Methods

The mobile laboratory was placed next to the hospital with plans to install fixed cardiac catheterization laboratories in 18 months. The unit had a C-arm system manufactured in 2008 (GE Medical system model 2359035). This was compared with a fixed laboratory manufactured in 2016 (Phillips Allura System 2016 installed with clarity software).

Absorbed dose measured in milligray (mGy), along with fluoroscopy time and frame count was documented for each case as reported by the Xray equipment. Effective operator dose measured in millisievert (mSv), was recorded by RAD-60R dosimeter (RADOS, Turku, Finland) placed outside of the lead apron worn by the operator on the left wrist for each case. In addition, de-identified patient and procedural data were collected including total contrast volume (mL), body mass index (BMI), procedure type (coronary angiography, percutaneous intervention, coronary bypass graft angiography, fractional flow reserve and intravascular ultrasound), number of horizontal radiation absorbing pads (HRAP) (yellow RADPAD® 0.25mm lead equivalent, Worldwide Innovations & Technologies, Inc., Kansas City, MO) and access site. We included access site and ranked them based on location given higher absorbed and effective dose with radial versus femoral access site [6], and right radial having possibly higher radiation exposure than left radial [7]. Access site was defined with femoral = 1, left radial = 2 and right radial = 3. Categorical variables were compared using Chi-square test. Normally distributed numeric variables were compared using student's-t test, and those not distributed normally were compared using Mann-Whitney U test. Normalcy of distribution was evaluated using Kolmogrov-Smirnoff test. A p-value < 0.05 was considered statistically significant.

Results

A total of 61 cases were studied. Of these, 30 procedures were performed in mobile catheterization laboratory and 31 in a fixed laboratory. There were no significant differences in BMI, access site, number of HRAP, contrast volume per case, frames per case and fluoroscopy time (Table). The fixed laboratory had significantly more PCI and graft angiography and trended to have more FFR/IVUS per case compared to the mobile laboratory. Absorbed and effective dose of radiation was significantly higher in the mobile laboratory compared to the fixed laboratory, (1884.17 mGy vs 691.23 mGy, p=0.005 and 0.030 mSv vs 0.0128 mSv, p=0.018), revealing over 2 ½ times more mGy in mobile versus the fixed laboratory and over 2 times the exposure when comparing mGy per frame and mSv (Figure 2).

Table 1: Comparison of case radiation modifiers and radiation exposure in a mobile and fixed catheterization laboratory.

	Mobile	**Fixed**	**p value**
BMI	31.17	32.36	0.546
Access	1.73	1.9	0.263
HRAP	1.97	1.97	0.982
Graft Angiography	0.33	1.8	0.014
FFR/IVUS per case	0.23	1.75	0.052
PCI	0.37	1.47	<0.005
Contrast (mL)	114.9	140.77	0.246
Frames per case	19.9	19.7	0.955
Flouro time (min)	11.94	17.09	0.256
Radiation			
Absorbed dose (mGy)	1884.17	691.23	0.005
Effective dose (mSv)	0.03	0.0128	0.018

HRAP: Horizontal radiation absorbing pad; Graft angiography: Number of grafts requiring angiography per case; FFR/IVUS: Fractional flow reserve or intravascular ultrasound studies per case; PCI: percutaneous coronary intervention - number of PCI per case; Flouro time: Fluoroscopy time in minutes; mGy: Milligray; mSv: Millisievert.

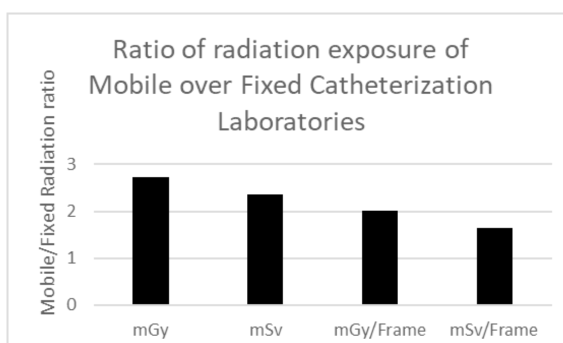

Figure 2: Graph representing the ratio of mobile compared to the fixed catheterization laboratory radiation exposure. Use of absorbed dose (mGy = milligray) and effective dose (mSv=millisievert) per frame.

Discussion

Mobile catheterization laboratories offer a bridge for hospitals to maintain access to invasive and interventional procedures, especially during periods of equipment failure or upgrades [1-3]. These mobile units offer the technology to patients who may not be in close proximity to fixed cardiac catheterization laboratories [3]. Patient selection for mobile laboratories has varied from only those who are qualified for outpatient procedures [1] to those with a prior myocardial infarction but no prior thrombolytic therapy [2]. Unfortunately, some mobile units can have Xray equipment that is decades old, which could translate into higher amounts of radiation exposure [4].

Our data show a significantly higher radiation burden to the patient and the operator in the mobile cardiac catheterization laboratory compared to fixed cardiac catheterization laboratories. This difference was not attributable to changes in patient's sight, access site, or any other variables listed.

Given the adverse stochastic as well as deterministic effects of radiation [5], these findings are of paramount importance with implications on patient safety as well as operator safety. The likely explanation of our findings is the older technology used by the mobile cardiac catheterization laboratory, which are not equipped with the contemporary radiation lowering electronic software as well as other algorithms.

Based on our data, when using mobile cardiac catheterization laboratories, a detailed examination of the capabilities of the imaging equipment should be performed. If contemporary mechanisms for lowering radiation burden are not available in the mobile unit, increase in shielding [8-10] as well as other measures to lower operator burden should be deployed as a minimum, with triage of procedures that typically have a higher radiation burden to the fixed cardiac catheterization laboratory. Accurate real time monitoring of radiation exposure using electronic dosimeters may be of value including establishment of thresholds for radiation safety.

These protocols for triage should also include the ability and feasibility of performing procedures such as insertion of mechanical support hardware, in the event of circulatory collapse, as well as the ability of multiple team members to be present in the confines of the mobile laboratory.

Conclusion

Mobile cardiac catheterization laboratories, although of great value in maintaining procedure throughput, their utilization with older Xray equipment is associated with a higher operator and patient radiation burden. Maximization of radiation monitoring, shielding, as well as patient selection could help mitigate this disadvantage. While mobile laboratories play an important role in providing access to cardiac catheterization procedures, Xray equipment may need updating to reduce radiation exposure.

Acknowledgements

Elizabeth A. Bisinov, MD thankful for her editing. Fairview Health Care systems and University of Minnesota Physicians.

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