

Reducing radiation exposure using very low frame rate (7.5 fps) fluoroscopy protocol during Chronic Total Occlusion Percutaneous Coronary Intervention

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“One of the main challenges in percutaneous coronary intervention (PCI), particularly in complex cases, is minimizing radiation exposure to ensure the safety of both patients and operators. Reducing the fluoroscopy frame rate is a straightforward and effective strategy to lower radiation dose without compromising technical success or, more importantly, clinical outcomes.”

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Introduction

Percutaneous coronary intervention (PCI) is a minimally invasive procedure used to treat stenosis or occlusions of the coronary arteries. It involves advancing a catheter through a peripheral artery—typically the radial or femoral artery—to the site of the lesion. A balloon is inflated to reopen the vessel, and a stent is often deployed to maintain patency. PCI is commonly performed to relieve symptoms of coronary artery disease (CAD), such as angina, improve myocardial perfusion, and reduce the risk of myocardial infarction. Compared to traditional coronary artery bypass grafting (CABG), PCI offers shorter recovery times and less procedural morbidity.

Chronic total occlusion (CTO) refers to a complete coronary artery blockage that has persisted for more than three months, usually due to advanced atherosclerosis. CTOs present unique technical challenges due to their complexity, duration, and the presence of calcified or fibrotic tissue, making revascularization more difficult and time-consuming.

It is well established that high levels of radiation exposure increase the risk of skin injury, tissue damage, and long-term malignancy. Radiation management is therefore a critical concern in CTO PCI, where procedural complexity often results in prolonged fluoroscopy time. Reducing X-ray dose is a key strategy to enhance safety for both patients and operators.

Usually, this kind of procedure is conducted under a standard frame rate fluoroscopy (SFF) of 15 frames per second (fps). A previous study with PCI data reported by Gupta et al. [1], has shown that lower frame rate fluoroscopy can reduce the radiation exposure without compromising the outcomes.

In this report, we demonstrate that radiation exposure can significantly be reduced, by using a very low frame rate fluoroscopy (VLFF) protocol of 3.75 and 7.5 fps while performing CTO PCI.

Methodology

Acquisition protocol

TCTO PCI was performed on an **Innova IGS 530**. Three groups of PCI patients were selected for comparison: the (Post) VLFF group consisting of 193 patients and the SFF (Pre VLFF) group with 133 patients (reported in the work of Gupta et al. [1]), and the CTO VLFF group from our database with 125 patients.

The imaging protocols for VLFF and SFF were as follows:

For VLFF, fluoroscopy at 7.5 fps was used for lesion assessment and stent positioning, while 3.75 fps was used for catheterization and guiding catheter setup at the operator's discretion. There was an increased use of fluoroscopy-store instead of cine for retrospective review. Cine was reserved for baseline angiography, assessing procedural complications, and the final angioplasty result, as well as for Stingray setup and re-entry. The use of collimation and filters was encouraged, and stent enhancement features were discouraged, both at the operator's discretion. IVI (intravascular imaging) usage was also encouraged at the operator's discretion.

For SFF, the standard protocol used 15 fps to perform both fluoroscopy and cine acquisitions.

The primary endpoint was radiation exposure to the patient, measured in the form of Air Kerma in milligray (mGy). The secondary endpoint was procedure-related and patient-related outcomes, specifically in-hospital Major Adverse Cardiovascular Events (MACE).

Baseline Characteristics

Baseline Characteristics	Pre VLFF (n =133)	Post VLFF (n = 193)	CTO VLFF – Personal data (n=125)
Age (Mean ± SD)	61 ± 11	60 ± 9	63±10
Male	110 (82.7%)	162 (83.9%)	79(63.4%)
Female	23 (17.3%)	31 (16.1%)	46(36.6%)
Procedural indication			
CSA	48 (36.1%)	69 (35.8%)	95 (76.3%)
ACS	85 (63.9%)	124 (64.2%)	30(23.8%)
EF (%)	48 ± 10	49 ± 11	55,99 ± 11

Table 1: . PCI patients' baseline characteristics reported by Gupta et al. [1] second and third columns versus Institutional data, 4th column.

RESULTS

Outcome	All (n =326)	NON-CTO Pre – VLFF (n = 133)	NON-CTO Post –VLFF (n= 193)	CTO VLFF – Personal data (n=125)	P value
Air kerma (mGy)	955 ± 69 528 (270 – 1135)	1714 ± 140 1197 (683- 2062)	433 ± 27 302 (206 – 517)	1788.3	< 0.0001 < 0.824
Contrast use (ml)	116.6 ± 3.8	116.7 ± 6	116.5 ± 4.9	221.11±106.29	< 0.0001 < 0.0001
Fluoroscopy time (mins)	16.06 ± 0.78	17.06 ± 1.29	15.38 ± 0.98	37.33±22.44	< 0.0001 < 0.0001
All-cause mortality	7 (2.1%)	3 (2.3%)	4 (2.1%)	2(1%)	0.911
MACE	12 (3.7%)	5 (3.8%)	7 (3.6%)	4(3%)	0.958

Table 2: . PCI outcomes reported by Gupta et al. [1] second and third columns versus Institutional data, 4th column.

Discussion

There was no significant difference in radiation dose between the CTO VLFF group and the non-CTO pre-VLFF group. This finding indicates that radiation dose management is effective in treating very complex lesions, achieving results comparable to treating non-CTO lesions without specific radiation management strategies.

However, contrast use was significantly higher in the CTO VLFF group compared to the non-CTO groups (both pre-VLFF and post-VLFF). This increase in contrast use can be attributed to the longer and more complex procedures required for the CTO group.

Fluoroscopy time was also significantly longer in the CTO VLFF group compared to the non-CTO groups (pre-VLFF and post-VLFF). This suggests that radiation management is effective in "buying" additional procedure time while maintaining low radiation doses.

Importantly, the VLFF protocol did not lead to worse clinical outcomes. It was found to be non-inferior to the standard radiation management strategy, indicating that the VLFF protocol is a viable option for managing radiation exposure without compromising patient safety.

Key Points

- **The use of VLFF protocol during regular PCI and CTO PCI is associated with highly significant reduction in radiation dose exposure without affecting fluoroscopy time, procedural outcome, and patient related outcomes.**

References

1. Gupta A, Chhikara S, Vijayvergiya R, et al. Radiation Exposure Reduction and Patient Outcome by Using Very Low Frame Rate Fluoroscopy Protocol (3.8 + 7.5 fps) during Percutaneous Coronary Intervention. Front Cardiovasc Med. 2021;8:625873. Published 2021 Feb 9. doi:10.3389/fcvm.2021.625873

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