Accuracy of Iodinated Contrast and Saline Delivery Using Piston-Driven and Peristaltic Power Injectors in CT

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

DEPARTMENT OF RADIOLOGY
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INTRODUCTION

Power injectors are used for automated injection of iodinated contrast media (ICM) in clinical practice for decades to provide controlled uniform flow [1]. The main types are piston- and peristaltic-based, both using positive-displacement pumps to deliver ICM [1]. Piston injectors push ICM from a syringe via a mechanical piston [2], while peristaltic injectors use rollers to advance ICM through tubing [1]. These differences may affect contrast delivery accuracy. The ICM volume, saline volume, and the flow rate are directly controlled by the power injector's settings. Hence, it is essential for the power injectors to be accurate to the prescription of ICM and saline solution based on the clinical protocol. There are several studies evaluating the performance of power injectors [1, 3-6]. To the best of our knowledge limited data exists evaluating the accuracy of ICM and saline volume injected by different power injectors using real clinical ICM protocols in CT.

PURPOSE

To assess the accurate delivery of iodinated contrast media (ICM) and saline flush volumes administered using piston-driven and peristaltic power injectors.

MATERIAL AND METHODS

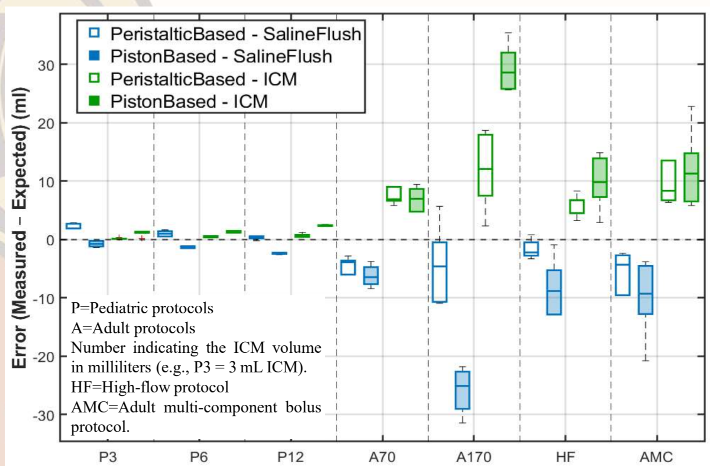
Seven clinically implemented injection protocols were executed using on both a piston-based injector and a peristaltic-based injector. The protocols represented patients from pediatric to bariatric populations, and incorporated variations in injection rate, contrast volume, saline volume, and contrast dilution. Reference ICM samples with accurately prepared iodine concentrations (5–20 mgI/mL) were scanned on a CT system (Discovery HD750, GE Healthcare) to generate a calibration relationship between CT attenuation and iodine concentration. For each injection, the saline test volume and the total volume of contrast plus saline flush were measured.

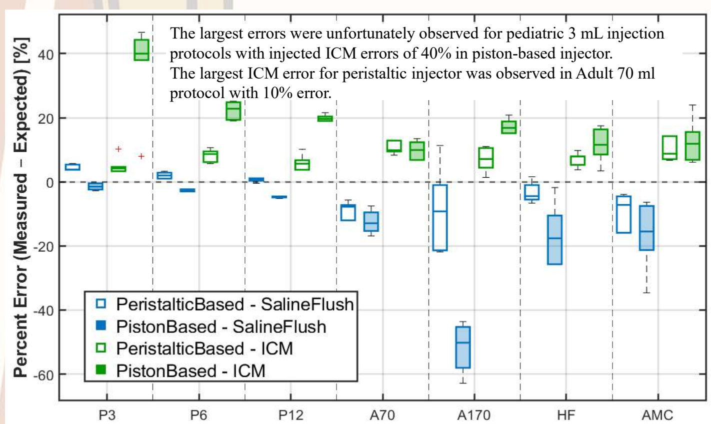
To quantify the relative contributions of contrast and saline, the combined mixture was diluted to 10 mg I/mL and rescanned. Measured CT numbers were converted to iodine concentrations using the calibration curve, and the original mixture concentrations were used to back-calculate the actual delivered ICM and saline volumes. Percent errors between expected and measured volumes were determined. A Wilcoxon signed-rank test assessed statistical significance.

Designed clinical contrast administration protocols used for evaluation of injector systems.

Protocol name	Test bolus [mL]	Iohexol 350 mg/mL [mL]	Saline flush [mL]	Flow Rate [mL/s]
Peds 3 mL	20	3	50	2
Peds 6 mL	20	6	50	2
Peds 12 mL	20	12	50	2
Adult 70 mL	20	70	50	3
Adult 170 mL	20	170	50	3
High flow	20	85	50	6
Adult, multi-component bolus	30	65 (main bolus), 10x3 mL (micro boluses) Total=95 mL	30 (main saline flush bolus), 10x3 mL (micro boluses) Total=60 mL	5

RESULTS





For the peristaltic-based injector, ICM volume error ranged from 4.0%–10.0% and saline flush error from 0.6%–9.2%. For the piston-based injector, ICM volume error ranged from 9.9%–40.0% and saline flush error from 1.5%–50.2%. Differences between expected and delivered volumes were statistically significant across protocols (p = 0.031/=0.035), except for peristaltic saline flush protocols (Ped 12 mL (p = 0.094), Adult 170 mL (p = 0.156), and High Flow (p = 0.093)).

CONCLUSION

Both injectors delivered excess ICM volume while saline flush volumes showed variability. These findings underscore the importance of performance verification to ensure accurate and consistent contrast delivery in clinical practice.

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Ulrich injector

Medrad injector

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ZAN, AS, RB, KS, CB, CG declare no conflicts of interest. MW HistoSonics Inc. (consultant, research support), Siemens Healthineers (research support), and Canon Medical (research support). T.P.S receives research support from Canon Medical Systems and GE HealthCare, consulting fees from Alara Imaging, Imalogix; royalties from Medical Physics Publishing and royalties related to intellectual property from Qaelum; founder of RadUnity. GT receives institutional grant from Canon Medical Systems.