RESEARCH LETTER

Comparison of Strategies to Conserve Iodinated Intravascular Contrast Media for Computed Tomography During a Shortage

In April 2022, a global shortage of iodinated contrast media occurred due to a COVID-19–induced supply chain disruption of GE Healthcare in Shanghai, China.[1] This shortage is expected to last until at least summer of 2022 and will affect millions of examinations.

Approximately 54.4 million diagnostic imaging examinations using contrast are conducted annually in the US, including nearly all angiography and 48% of the 91.4 million computed tomography (CT) scans performed in 2019.[2,3]

Strategies to minimize patient harm include canceling or delaying tests that have little patient benefit or are not time sensitive. For indicated examinations, alternative tests with similar diagnostic accuracy could be considered.

For CT examinations that usually use contrast, several approaches could potentially conserve contrast. For example, unenhanced CT can have similar or only modestly lower diagnostic accuracy as contrast-enhanced CT for many indications. The volume of administered contrast can be reduced by using weight-based dosing,[4] lower tube voltage,[5] or a combination of these methods. At present, there is no standard contrast dosing strategy across centers.[4] Additionally, there are different strategies for delivering contrast, and fixed-volume vials (in which the residual is discarded) result in waste compared with multidose vials.[4] We modeled the amount of contrast that could be conserved in CT examinations.

Supplemental content

Methods | We considered 5 alternative strategies for conserving contrast during CT imaging: weight-based dosing[4] (model A), reducing contrast dose while reducing tube voltage[5] (model B), replacing contrast CT with unenhanced CT if no more than moderate negative effect on diagnostic accuracy is predicted using the American College of Radiology Appropriateness Criteria[6] (model C), a combination of models A and C (model D), and a combination of models A, B, and C (model E) (**Table 1**). The eTable in the Supplement provides the detailed rules of each contrast-conserving strategy by clinical indication. We applied these rules to observed contrast use in each examination in a sample of 1.04 million CT examinations in the UCSF International CT Dose Registry performed January 1, 2015, to March 11, 2021, to estimate total expected contrast use at baseline (40% of scans used contrast in the registry during included years) and in each of the 5 hypothetical strategies (eMethods in the Supplement). All contrast volumes were modeled using an iodine concentration of 300 mg iodine/mL. The registry pools consecutive CT scans performed at 161 imaging facilities associated with 27 health care organizations.[7] We scaled the results (using data on age, weight, indication, and contrast use) to a hypothetical population of 1 million CT scans in adults and calculated percent reductions in total contrast usage from baseline. The base case assumed multiuse vials were available. The sensitivity analyses assumed practices had access to typical single-use vials of various doses (excess volume wasted). Simulations used SAS, version 9.3 (SAS Institute).

Table 1. Model Assumptions

Model/analysis	Description
Base model[a]	Fixed dosing: 100 mL for brain CT; 120 mL for neck, chest, abdomen, pelvis, spine, and extremity CT; 10 mL for myelograms
A: Weight-based dosing for nonneurological CT	Weight-based dosing applied to abdomen, chest, cardiac, spine, and extremity imaging: 1.4 mL/kg up to a maximum dose of 120 mL[3] Fixed dosing of 100 mL for neurological CT and 10 mL for myelograms
B: Reduce kV and contrast media dose if patient weight is <80 kg	Patients <80 kg: tube voltage reduced from 120 kV to 80 kV with 40% reduction in contrast media dose[5] Patients ≥80 kg: No change in contrast media dose. Does not apply to CT myelograms, trauma CT, transplant CT, or CT examinations that rely on CT number calculations
C: Perform unenhanced CT instead of contrast-enhanced CT if predicted to have moderate or less effect on accuracy	All contrast-enhanced CT examinations in which contrast media not essential were changed to unenhanced examinations (see eTable in the Supplement); this reflects most nonvascular examinations and is based on American College of Radiology Appropriateness Criteria[6]
D: Combination of models A and C	Weight-based dosing for nonneurological CT, combined with use of unenhanced CT if contrast not essential
E: Combination of models A, B, and C	Weight-based dosing for nonneurological CT, combined with reduced kV and reduced contrast dose for patients <80 kg and use of unenhanced CT if contrast not essential
Sensitivity analysis 1: fixed dosing; 20-, 50-, and 100-mL single-use vials available[b]	20-, 40-, 50-, 60-, 70-, 80-, 90-, 100-, 110-, and 120-mL doses possible from available vials without waste; other doses rounded up to these values and the total estimate includes the resulting waste
Sensitivity analysis 2: fixed dosing; only 50-mL vials available[b]	50- and 100-mL doses possible without waste; other doses rounded up to 50, 100, or 150 mL and the total estimate includes the resulting waste
Sensitivity analysis 3: fixed dosing; only 100-mL vials available[b]	100-mL doses possible without waste; other doses rounded up to 100 or 200 mL and the total estimate includes the resulting waste

[a] The distribution in patient age, weight, type of examinations by body region, and indication for scanning and use of iodinated intravenous contrast across these patient variable and computed tomographic (CT) types (see eTable in the Supplement) was based on their distribution in the University of California San Francisco International CT Dose Registry.[6]

[b] In normal conditions without supply chain compromise, contrast is available in multiuse vials (in which exact volumes can be given to multiple patients but requiring a particular type of contrast injector) and single-use vials (can be given to individual patients, with or without combination of several single-use vials, where excess volume must be discarded). When all vial sizes are available, this is similar to exact dosing without access to the particular type of contrast injector.

Results | For the base case, 47.1 million mL of contrast was estimated to be used for the 1 million CT scans (**Table 2**). The model estimated that weight-based dosing would reduce use by 12% (to 41.6 million mL) and that reducing tube voltage and

Table 2. Estimated Use of Intravenous Contrast Media (300 mg Iodine/mL) Under Different Scenarios for Conserving Use in a Modeled Population of 1 Million US Adults[a]

Model	Multiuse vials exact dosing, mL	Single-use vials available[b]		
		20, 50, and 100 mL	50 and 100 mL	100 mL
Baseline	47 125 410	47 149 640	58 589 480	77 655 880
A: Weight-based dosing for nonneurological CT	41 587 660	42 680 090	52 228 400	64 983 650
Reduction, %	12	9	11	16
B: Reduce kV and contrast media dose for patients <80 kg	35 441 330	35 776 420	42 635 220	62 112 100
Reduction, %	25	24	27	20
C: Perform unenhanced CT instead of contrast-enhanced CT if predicted to have moderate or less effect on accuracy	10 477 420	10 477 420	13 053 520	17 347 010
Reduction, %	78	78	78	78
D: Combination of models A and C	9 390 820	9 609 910	11 824 800	14 899 430
Reduction, %	80	80	80	81
E: Combination of models A, B, and C	7 812 000	7 933 770	9 447 450	13 693 130
Reduction, %	83	83	84	82

[a] Data are total volume in mL and percent reduction in mL compared with the baseline models. The model inputs were based on a sample of 1.04 million computed tomography (CT) examinations from the University of California San Francisco International CT Dose Registry[6] that had nonmissing patient age, body weight, CT examination types by indication, and use of contrast across these patient factors (see eTable in the Supplement), scaled to a population of 1 million adults.

[b] Patient dose does not vary between multiuse and single-use estimates. The higher estimated volumes associated with single-use vials reflect waste from discarded unused volume.

contrast dose would reduce use by 25% (to 35.4 million mL). The model estimated that the greatest reduction (78% [to 10.5 million mL]) would involve performing unenhanced CT instead of contrast-enhanced CT when moderate reduction in diagnostic accuracy is acceptable. Combining all 3 approaches was estimated to achieve an 83% reduction (to 7.8 million mL) (Table 2). The base case estimate for single-use 100-mL vials would be 77.7 million mL vs an estimated 47.1 million mL for multiuse vials, but the relative benefits of the different reduction strategies are similar.

Discussion | This modeling study estimated that intravenous contrast use for CT scans could be reduced by approximately 80% by using a combination of dose-reduction strategies. This analysis had several limitations. The lower prevalence of contrast use in the registry (40%) vs the national estimate (48%) indicates that the percent reductions calculated in the various strategies are underestimated. The reduction in diagnostic accuracy and potential harm to patients from withholding contrast was not modeled, nor was repackaging of larger single-use vials to smaller single-use vials. The study was limited to CT scans, but other examinations, particularly catheter angiography, also use contrast. Adoption of some of the dose-reduction strategies beyond the current shortage could mitigate supply chain risk and remove waste.

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Author Contributions: Dr Smith-Bindman had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: All authors.
Acquisition, analysis, or interpretation of data: Davenport, Chu, Smith-Bindman.
Drafting of the manuscript: All authors.
Critical revision of the manuscript for important intellectual content: All authors.
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Supervision: Smith-Bindman.

Conflict of Interest Disclosures: Dr Davenport reported receiving personal fees from Wolters Kluwer for book royalties (book, and for uptodate.com) outside the submitted work; and being the vice chair of the commission on quality and safety and former chair of the committee on drugs and contrast media for the American College of Radiology and on the board of directors for the Society of Advanced Body Imaging. Dr Szczykutowicz reported being a consultant to Imalogix, AstoCT, Flowhow.ai, AiDoc, and Alara Imaging; receiving research support from Canon Medical USA and GE Healthcare; licensing technology to Flowhow.ai and Qaelum; and receiving royalties from Medical Physics Publishing. Dr Smith-Bindman reported being a co-founder of Alara Imaging, a company focused on collecting and reporting radiation dose and imaging quality information for computed tomography. No other disclosures were reported.

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