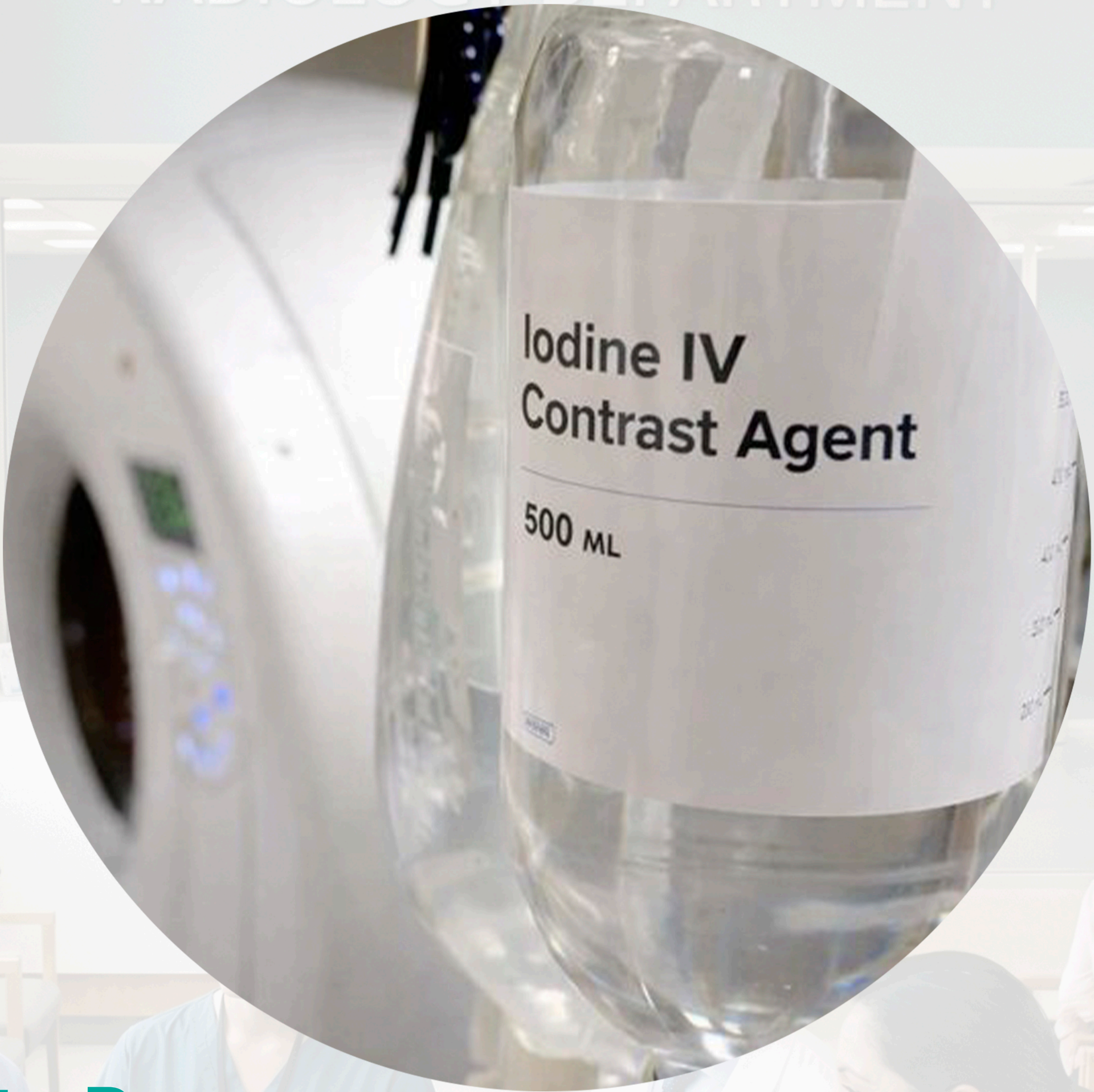

White Paper

How to Reduce Iodinated IV Contrast Usage by Up to 20% Without Compromising Diagnostic Image Quality

Evidence-Based Strategies for CT Optimization.

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1. Introduction

Iodinated IV contrast agents are indispensable for diagnostic CT imaging, yet they account for a significant portion of consumable costs and supply-chain risk. With the global emphasis on sustainability, dose optimization has evolved from a cost-saving measure into a clinical and regulatory requirement.

Recent advances in detector technology, iterative reconstruction, and dual-energy CT now make it possible to **achieve target contrast enhancement with up to 20% less iodine**, preserving or even improving image quality.

2. The Physics Behind "Less Iodine, Same Contrast"

Iodine strongly attenuates X-rays at lower photon energy (~33 keV). When scanning at lower tube voltages (80–100 kVp), the mean photon energy approaches this range, thereby **increasing iodine conspicuity** per milligram administered.

This relationship allows radiologists to **decrease the iodine dose while maintaining identical vascular or organ enhancement**, particularly when noise reduction algorithms such as **iterative or deep learning reconstruction** are used.

Clinical trials consistently demonstrate:

- **~20% reduction** in iodine volume feasible at **100 kVp**
- **~40% reduction** achievable at **80 kVp** for non-obese patients

3. Primary Optimization Strategies

3.1. Low-kVp Protocols with Iterative Reconstruction

Approach:
For patients with **BMI ≤ 30 kg/m²**, reduce tube voltage from 120 kVp to 100 kVp (or 80 kVp when appropriate). Adjust mAs or rely on automatic exposure control to maintain noise equilibrium.

To ensure diagnostic consistency when reducing iodine volume, technical staff must manage the **Iodine Delivery Rate (IDR)**. IDR is the amount of iodine (in grams) delivered to the patient per second.

The IDR Formula

$$IDR\ (\mathrm{g\ I/s}) = \frac{\mathrm{Concentration\ (mg\ I/mL)} \times \mathrm{Flow\ Rate\ (mL/s)}}{1,000}$$

Practical Example: 20% Reduction Protocol

Scenario: A CTA scan for an **80 kg patient** using **370 mg I/mL** contrast.

Step 1: Establish the 120 kVp Baseline

- Patient Weight: 80 kg
- Standard Volume: 1.5 mL/kg = 120 mL
- Injection Flow Rate: 5 mL/s
- Scan Time: 24 s (120 mL / 5 mL/sec)
- Baseline IDR Calculation: (370 mg/mL X 5 mL/s) / 1000 = 1.85 g I/s

Step 2: Apply the 20% Reduction for 100 kVp

Because 100 kVp increases iodine conspicuity, we can reduce the total volume by 20%.

- New Target Volume: 120 mL X 0.80 = 96 mL
- Savings: 24 mL of contrast per exam.

Step 3: Set New Injection Parameters

To maintain the same arterial opacification timing, we adjust the IDR based on the increased conspicuity at 100 kVp.

- Revised Flow Rate: To deliver the reduced volume 96 mL over a similar bolus duration, the technologist uses:
- Volume: 96 mL
- Flow Rate: 4.0 mL/s (adjusted to ensure the bolus lasts through the scan duration: 96 mL / 4 mL/sec= 24 s scan time).
- Modified IDR: (370 mg/mL X 4 mL/s) / 1000 = 1.48 g I/s

Technical Tip: When dropping to 100 kVp, the "visual" brightness of the iodine increases. Even with 20% less total iodine, the Hounsfield Units (HU) in the aorta or liver typically remain equal to or higher than the 120 kVp baseline

Clinical impact:

- **~20% iodine dose reduction** at 100 kVp
- Maintained or improved organ enhancement
- Compatible with all modern iterative reconstruction algorithms

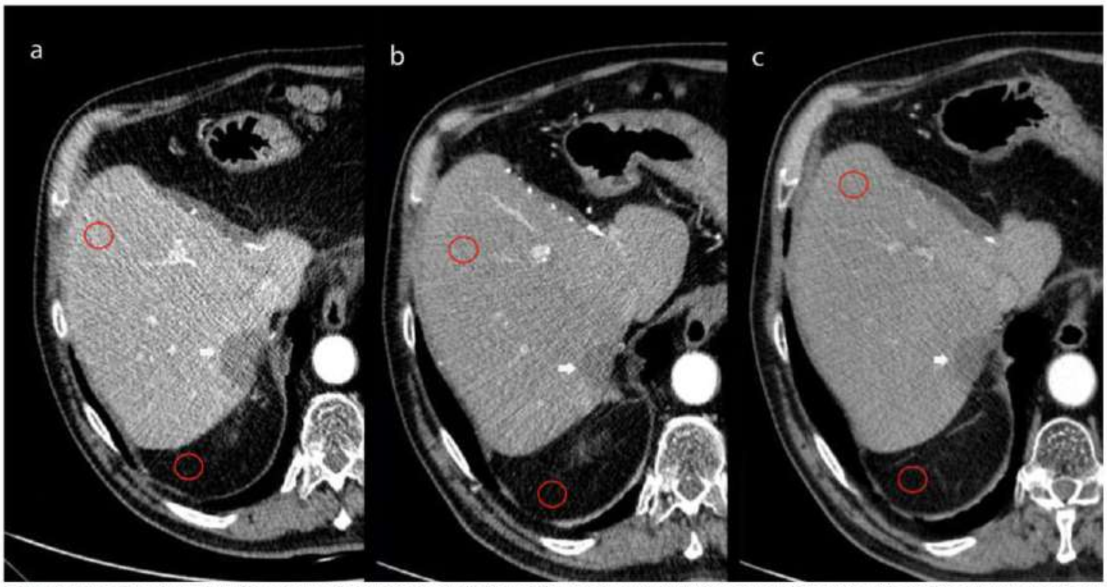


Figure 1. Hepatic mean attenuation measured through one of the three ROIs placed over the fifth segment of the liver and one ROI drawn in peritoneal abdominal fat adjacent to the liver avoiding strands. Images obtained at 80kV (a), 100kV (b), and 120 kV (c).

Emilio Quaia (2016) Comparison between 80 kV, 100 kV and 120 kV CT protocols in the assessment of the therapeutic outcome in HCC. Liver Pancreat Sci, 2016.

3.2. Saline Chaser and Dual-Syringe Injector Optimization

Approach:
Administer a **30–50 mL saline flush** immediately after contrast at identical flow rate (4–6 mL/s). This clears the tubing, sharpens the bolus, and increases vascular contrast efficiency.

Impact:

- **16–30% potential iodine savings** documented in abdominal and thoracic CTA
- Improved arterial enhancement uniformity and reduced streak artifacts (*Dorio PJ et al., AJR; Behrendt FF et al., Eur J Radiol 2010*).

Protocol example (Abdominal CT):
Contrast 70–80 mL → Saline 40 mL @ same flow. Use bolus tracking to confirm timing.

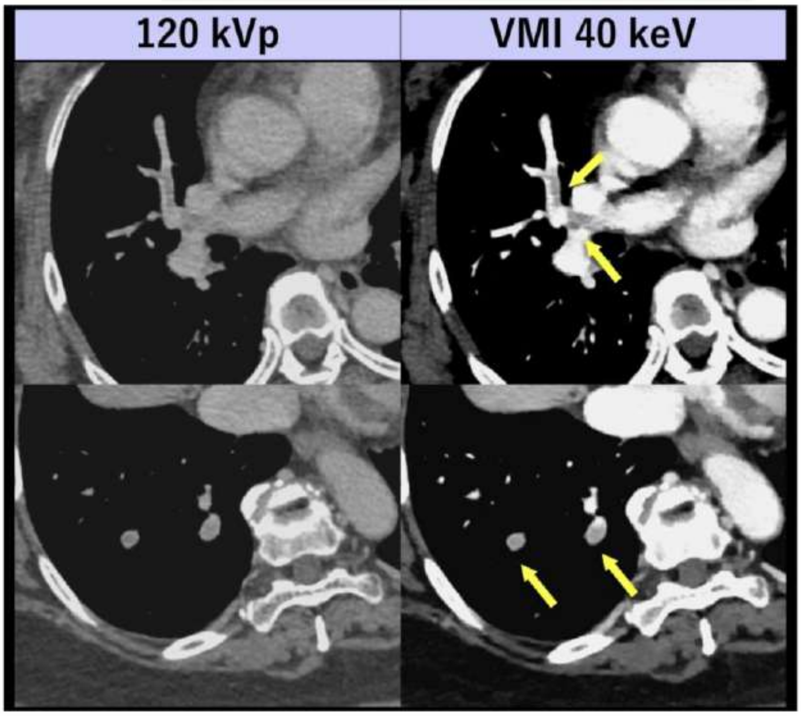
3.3. Dual-Energy CT (DECT) with Virtual Monochromatic Imaging (VMI)

Approach:
For sites with DECT capability, reconstruct **Virtual Monochromatic Images (VMI)** at **40–60 keV**.

Impact:

- Enables **30–50% reduction** in contrast volume while preserving diagnostic confidence
- Particularly effective in **angiography, urography, and oncology follow-ups**

Protocol example (Abdomen, portal venous phase):
0.8–1.0 mL/kg of 300–350 mg I/mL vs standard 1.2–1.5 mL/kg; reconstruct VMI at 50 keV. Confirm HU targets for liver and vessel enhancement.
(*Shuman WP et al., AJR 2019; Cester D et al., QIMS 2022*).



A 66-year-old woman with breast cancer who underwent portal venous phase CT using dual-layer detector scanner. Incidental PEs (arrows), which may be missed on 120 kVp images due to suboptimal contrast enhancement in the pulmonary arteries, are confidently detectable on VMI 40 keV without the need for dedicated CTPA

Nagayama Y. Contrast medium dose optimization in the era of multi-energy CT. Eur Radiol 2025.

4. Secondary Optimization Measures

Weight-Based Dosing
Transition from fixed contrast volumes to **mL/kg dosing** for consistency across patient sizes. Maintaining constant IDR ensures uniform enhancement. (ACR 2025; ESUR v10)

Timing Optimization
Implement **bolus tracking** for individualized scan delays (e.g., 100 HU trigger in aorta). Reduces wasted enhancement and prevents premature scanning. (*PubMed clinical evidence*).

Contrast Concentration Adjustments
Select iodine concentration (300–370 mg I/mL) based on injection system capacity and access gauge to balance flow and total iodine delivery.

Protocol Governance
Establish BMI cut-offs for 80/100/120 kVp protocols. Lock presets on the scanner console. Perform monthly audits to verify enhancement goals and contrast use per study type.

5. Quality, Safety, and Clinical Governance

Both **ACR** and **ESUR** guidelines emphasize that optimization should **never compromise diagnostic adequacy**. Lower iodine loads align with:

- Patient safety in renal impairment
- Supply stewardship during global shortages
- Institutional sustainability and cost control

Comprehensive QA should monitor:

- Enhancement metrics (HU targets per exam)
- Repeat or non-diagnostic rates
- Iodine use per protocol normalized to body weight

Hydration and allergy risk assessments remain mandatory regardless of dose reduction strategies.
(*ACR Manual on Contrast Media, 2025; ESUR Guidelines v10*).

6. Clinical Outcomes and Economic Benefits

When implemented systematically, the combined strategies yield:

Metric	Typical Improvement
Average contrast reduction	**20 %**
Diagnostic enhancement levels	Maintained or ↑
Repeat/excluded scans	↓ by 20–40 %
Annual cost savings (mid-volume site, 20,000 CT exams/yr)	≈ USD 40–60k
Radiologist confidence	Unchanged or improved

Published evidence consistently supports these figures across a range of scanners and body regions (*Nagayama Y 2025; Shuman WP 2019; Yu L AJR; Cester D QIMS 2022*).

7. References

- **American College of Radiology (ACR)**. *Manual on Contrast Media*, 2025 Edition. https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Contrast-Manual
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- **Dorio PJ et al.; Orlandini F et al.** *Using a Saline Chaser to Decrease Contrast Media in Abdominal CT. AJR. https://www.ajronline.org/doi/10.2214/ajr.180.4.1800929?doi=10.2214/ajr.180.4.1800929*
- **Behrendt FF et al.** *Effect of different saline chaser volumes and flow rates on intravascular contrast enhancement in CT using a circulation phantom. Eur J Radiol 2010. https://www.sciencedirect.com/science/article/abs/pii/S0720048X09000151*

Summary Insight
By leveraging physics-based contrast optimization and precise injector control, **imaging centers can confidently reduce iodinated contrast usage by 20%,** aligning financial savings with responsible, evidence-based patient care.

