CT Contrast Delivery: Managing Injection Pressure Through Warming

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Executive Summary

Advances in CT acquisition speed, detector coverage, and high-flow injection protocols have increased contrast delivery demands. Successfully achieving the prescribed contrast flow rate depends on multiple factors, including IV access and placement, contrast concentration and viscosity, injection volume and duration, patient size and characteristics, and scan time and characteristics. Because contrast viscosity increases resistance to flow, it can contribute to higher injection pressures and difficulty maintaining the prescribed flow rate.

Contrast temperature is a modifiable factor that directly affects viscosity. Warming iodinated contrast media to 37°C, human body temperature, reduces viscosity and the resistance to flow. The American College of Radiology recognizes that warming can reduce the viscosity of iodinated contrast media, and may be considered in certain circumstances, particularly with higher-viscosity agents.

Despite previous success with contrast media warming, some CT departments discontinued the practice after weighing operational and quality assurance (QA) demands associated with Joint Commission expectations. However, as CT protocols and contrast-delivery practices have evolved, attention has returned to the potential value of contrast warming and maintaining consistent contrast temperatures throughout the delivery pathway.

Achieving that consistency involves more than warming contrast to a specified temperature; maintaining it through injection requires a consistent approach to monitoring, storage, and workflow. Associated QA requirements also must be met, including documentation of contrast stock rotation and usage in accordance with the prescribing information for each contrast bottle.

Technologies that integrate warming and temperature management into the contrast delivery system—such as CT syringeless injector systems with integrated warming and temperature-management features—offer a practical approach to streamlining these processes. For multidose contrast, the location of the warming mechanism can also affect temperature consistency across doses. Systems that position temperature management components directly at the bulk contrast bottles, for example, can maintain contrast temperature as the containers are drawn down, helping to keep the contrast warm until delivery. Importantly, warming is only one component of a broader strategy to promote consistency across the contrast delivery pathway and standardize protocols throughout a network of CT departments.



"When injection pressures become a limiting factor, it's important to look at the entire delivery apparatus, and warming contrast can be one way to reduce resistance and help maintain the prescribed flow rate."

–Corey Jensen, MD

ACR Guidance for Warming Contrast

Warming contrast lowers viscosity and reduces injection resistance, but more specific clinical advantages including patient comfort and diagnostic enhancement are less clearly demonstrated in research amid anecdotal reports of benefits.[1] The American College of Radiology, in its *Manual on Contrast Media*,[1] notes:

> **"Patients injected with more viscous contrast material may be more likely to have extravasations than patients injected with less viscous contrast material. This effect may be mitigated for viscous media by extrinsic warming to human body temperature prior to injection."**

Viscosity of iodinated contrast may vary and is affected by the amount of iodine in the select vial/bottle, known as the agent's concentration. The higher the concentration, the higher the viscosity (e.g. 370 mg (I)/mL).

The ACR manual cites a lack of supportive evidence for "routine warming of low-osmolality, lower-viscosity iodinated contrast agents," noting "some evidence that the warming of low-osmolality, higher-viscosity iodinated contrast agents may decrease the rate of contrast extravasations." It also notes that data are "inconsistent and insufficient to recommend its routine practice when considering the logistics involved."

The ACR suggests considering iodine-based contrast media warming to reduce viscosity in certain circumstances, noting that this may indirectly "reduce the risk of extravasation by decreasing resistance during intravascular injections in certain high-risk patients to improve iodine-based contrast flow and reduce injection pressure."[1]

Contrast Warming in CT

Contrast temperature is a modifiable factor that influences contrast viscosity, injection pressure, and iodine delivery. As CT protocols increasingly require higher injection rates, managing viscosity becomes important in consistently achieving prescribed flow rates, iodine delivery, and consistent imaging protocols across a network of scanners. Warming contrast media to 37°C reduces viscosity and injection pressure,[1] which may be relevant when using higher-flow injections.

CT technology continues to advance with faster acquisition speeds and wider detector coverage to capture more anatomy in less time, which places greater demands on timed contrast delivery. Many factors can impact the complete contrast delivery pathway and the ability to achieve prescribed flow rates including patient body size and cardiac output; IV access catheter size and location; contrast concentration and viscosity; injection volume and duration; and scan speed and timing. Of these, contrast viscosity can be managed before the injection begins.

"Higher viscosity agents have been shown to increase the risk of extravasation at ambient/room temperature, an effect which is reduced by contrast warming," says Nakul Gupta, MD, Vice-chair of Technology and Translational Imaging at Houston Methodist Hospital System. "Regrettably, high iodine content agents that are best suited for specific imaging protocols such as coronary angiography are more viscous agents. We view contrast warming as a modifiable risk factor that improves coronary enhancement and minimizes patient harm."

Although the advantages of warming contrast to lower its viscosity and reduce resistance during injection are well documented,[1] evidence that recommends warming to support specific clinical advantages is less clear, according to the American College of Radiology *Manual on Contrast Media*.[1] Over the years, as some practices weighed operational demands, like meeting stringent Joint Commission requirements against uncertain clinical benefits, many reconsidered or eliminated their contrast warming practices. Today, increasingly demanding CT protocols have renewed attention on the importance of consistent injector performance and maintaining contrast temperature throughout the injection pathway.

Lower Viscosity Supports More Consistent Contrast Delivery

High-flow rate protocols that depend on delivering a precise contrast bolus within a narrow acquisition window, especially for cardiac applications and perfusion, make low viscosity, consistent injection pressure, and contrast temperature critical, according to Pam Mager, RT(R)(CT), Enterprise Manager of Clinical CT Imaging Physics at Houston Methodist.

"There's a demand to deliver the contrast as effectively, efficiently, and consistently as possible," Mager notes of increasingly complex technology and faster speeds.

Computed tomography angiography (CTA) and contrast-enhanced cardiac CT imaging depend heavily on carefully controlled contrast timing, injection rate, concentration, and temperature to achieve consistent vascular enhancement. Warming contrast to reduce its

viscosity allows the contrast to flow more smoothly through the IV catheter with less injection pressure. While the ACR guidelines do not note evidence to support improved patient tolerance through warming, Carrie Bartels, RT(R) CT, Senior CT Technologist on the CT Protocol Team at UW Health, Radiology, in Madison, WI, describes her department's challenges associated with higher-viscosity contrast media.

"Higher-viscosity contrast media require greater injection pressure, which can make administration more challenging, particularly in patients with smaller or fragile veins. This may increase risk of injection-related complications, such as contrast extravasation, and can affect patient comfort," Bartels says.

During contrast administration, factors that increase injection resistance—including high contrast viscosity, small-gauge IV catheters, longer tubing, and other sources of flow restriction—can limit achievable flow rates, alter contrast bolus delivery, and potentially compromise image enhancement.[2] Patient-related factors, including cardiac output, also influence contrast circulation and image enhancement.[3] As CT power injectors approach preset pressure limits designed to prevent excessive pressure, safety features engage to reduce flow rate or activate a pause feature, creating workflow interruptions. In applications at UW Health, properly warmed contrast yielded lower viscosity to improve injection efficiency, reduced injector pressure alarms, and minimized delays caused by troubleshooting IV access or common injection issues to facilitate efficient patient throughput and reduce repeat scans.

"By warming contrast, we had fewer injector pressure alerts, more consistent achievement of programmed flow rates, smoother contrast bolus delivery, and improved reliability of high-flow injections," Bartels reports, noting that the changes were especially noticeable when using larger contrast volumes and higher iodine delivery rates where viscosity has a greater impact on injection dynamics.

The practical benefits of contrast viscosity reduction became apparent in another case example at UT MD Anderson in Houston. After transitioning to a higher concentration iodinated contrast agent, the department observed more frequent pressure-limit injections, particularly through implanted ports. An evaluation found that improving the injection pathway—including larger-bore needles and tubing, along with the administration of warmed contrast—substantially reduced pressure peaks and restored intended injection rates.[4]

"When injection pressures become a limiting factor, it's important to look at the entire delivery apparatus, and warming contrast can be one way to reduce resistance and help maintain the prescribed flow rate," according to Corey Jensen, MD,

Viscosity and Contrast Warming

Viscosity varies among iodinated contrast media and decreases substantially when the contrast is warmed to body temperature.

Warming reduces viscosity: Across the contrast agents evaluated, dynamic viscosity decreases by about half when warmed from room temperature (20-25°C) to body temperature (37°C).

Higher concentration generally means higher viscosity: Contrast media with higher iodine concentrations, such as 370-400 mg(I)/mL, generally have higher viscosity than lower-concentration agents at both room and body temperature.

Dynamic viscosity is measured in centipoise (cP), a unit of resistance to flow. As temperature increases, viscosity decreases.

Source: American College of Radiology. *Manual on Contrast Media. Appendix A: Contrast Media Specifications. 2026.*

QA Considerations

Because iodinated contrast media is considered a medication, warmed contrast may be subject to Joint Commission considerations related to medication handling, patient safety, and equipment management. Departments may therefore consider adopting site-specific procedures that address the following:

- **Temperature monitoring:** Verify that the warmer reaches and maintains the manufacturer-recommended temperature, commonly 37°C.
- **Storage duration:** Monitor how long contrast remains in the warmer and ensure it's used within manufacturer guidelines.
- **Documentation:** Maintain temperature logs and/or document the "time in" and "time out" schedule for each contrast media bottle in the warmer.
- **Equipment maintenance:** Complete and document preventive maintenance, calibration, and recommended performance checks for warming equipment.
- **Policies and procedures:** Establish clear, site-specific protocols for warming, storing, and administering contrast.
- **Staff training:** Provide training on the operational protocol of the warming equipment and institutional warming procedures, with documentation of competency/education.

Having clear protocols, maintenance records, and staff education documentation demonstrates compliance with Joint Commission expectations and safe care regulations.

Syringe-Based Injection Vs. Syringeless Technology

Syringe injector systems	Syringeless injector systems
Manual prep: Technologists must transfer contrast into an empty syringe before each imaging exam.	**Simplified prep:** Multi-dose contrast containers connect directly to the injector, reducing manual steps and contrast and consumables waste.
Repeated loading: Contrast and saline syringes are loaded, changed, and prepared between patients.	**Fewer manual steps:** The system does not require repeated loading and replacing of syringes.
Manual warming and maintenance: Contrast bottles are warmed separately, with temperature reduction occurring during transfer.	**Integrated heat maintainers:** Contrast must first be independently warmed, and is maintained to 37°C by the injector.
Temperature monitoring: Temperature checks and documentation are manual processes.	**Automated monitoring:** The injector system monitors the contrast temperature and captures documentation.
Workflow variability: Preparation and warming practices, including the use of contrast warmers and warming sleeves, vary by technologists and departments.	**Greater consistency:** Contrast preparation, heat maintenance, and delivery is standardized across scans via system automation features.
QA burden: Temperature logs, warming equipment, and other functions require staff oversight with consistent documentation.	**Streamlined QA:** Integration of heat maintainers and monitoring processes reduces manual documentation and demands of QA tasks.
Waste considerations: Contrast left in a prepared syringe is usually discarded after the exam.	**Single-use delivery:** Contrast is delivered right from the container, minimizing waste and the need for disposable syringes.

Director of Abdominal CT Imaging at UT MD Anderson.

As noted, warming contrast should be viewed as one component of an overall strategy to optimize safe contrast administration during high-flow injections.

Compliance and Comfort Without Compromise

Quality assurance plays a critical role in contrast warming to ensure patient safety, maintain regulatory compliance, and support consistent contrast delivery. Although processes vary according to established institutional guidelines and the warming technology used, departments must account for storage requirements, monitoring contrast stock rotation, equipment maintenance—including temperature monitoring—and ensuring that staff education includes written QA protocols with observations and documentation.

While QA considerations are manageable, they add workflow steps that can become burdensome in departments where contrast use is intermittent or where exams are subject to delays. Like many institutions, these considerations eventually led UW Health, which had been warming contrast for decades, to discontinue its warming programs. As a result, the department experienced a "small uptick in IV infiltrations," or contrast extravasations, according to Bartels.

Similarly, requirements such as maintaining a temperature log, "were actually deterring some of our community hospitals from warming," Mager says of Houston Methodist satellite locations. From an injection-performance perspective, however, unwarmed contrast presents a trade-off: room-temperature contrast has higher viscosity, which increases resistance to flow and may require higher injection pressures.

Today, both Houston and UW Health warm contrast to 37°C. Operationally, maintaining the temperature until the administration of the contrast presents the greatest challenge, because it gradually cools after removing from the warmer,

Workflow Savings of a Syringeless System

GE HealthCare's CT motion syringeless injector, manufactured by ulrich medical, outperformed a single-use syringe injector in terms of workflow efficiency, ease of use, and overall performance, with technologists spending 63.6 seconds less per patient in the scan room.*

**Toia G, et al. Consumable material waste and workflow efficiency comparison between multi-use syringeless and single-use syringe-based injectors in computed tomography.* Acad Radiol. *2023;30(10):2340-2349. doi:10.1016/j.acra.2023.05.038*

with the greatest loss occurring during the first 15 to 30 minutes. Injector-mounted warming sleeves may help maintain prewarmed contrast, but their effectiveness can vary based on positioning and operator use.

These challenges have prompted a shift toward more integrated approaches that reduce the number of manual steps required to maintain contrast temperature and support consistent iodine delivery. CT departments can more readily incorporate contrast warming into the injection workflow by using a syringeless injector system with built-in heat maintainers. This advanced injector technology reduces manual preparation and streamlines contrast delivery management. The technology can also address some of the storage, temperature maintenance, and handling challenges associated with conventional warming practices.

Integrating Contrast Warming Into CT Workflow

Syringeless injector systems consider the entire contrast delivery pathway for better preservation of temperature until the administration of the contrast injection, which, in turn, supports smoother, consistent contrast delivery and lower injection pressures. While the amount of temperature maintenance varies by injector system and departmental workflow, in general, syringeless systems present fewer opportunities for temperature loss, thus simplifying the warming process.

With multidose contrast delivery, where the warming mechanism is located impacts how consistently contrast temperature is maintained across doses. Maintaining the contrast temperature at the bulk vial helps ensure that it remains warmed between doses, supporting consistent temperature across the full dosing sequence.

"Modern injector systems maintain the contrast temperature even after it's been removed from the warmer and loaded into the injector, which can be a huge difference-maker if there's a lag between when the injector is loaded and when the patient is ultimately scanned. Being able to control as many variables as possible certainly aids in getting consistent results," Gupta says.

Advances in injector technology allow systems to respond to increasing injection pressure by incrementally reducing the flow rate rather than stopping the injection. This approach can help maintain contrast delivery when pressure limits are reached and support consistent imaging.

"Pressure limited injections result in marked drop-off of injection rate and poor opacification, with the degree of impairment depending on how soon the injection was cut off," explains Gupta.

Conclusion

As contrast injection protocols become more demanding, maintaining contrast temperature is an important component of consistent, reliable contrast delivery. An integrated approach that combines temperature maintenance, pressure management, quality assurance, and standardized workflow can help reduce variability across CT examinations and departments. By automating temperature monitoring and other aspects of contrast delivery, syringeless injector systems may further reduce manual steps and support greater consistency throughout the injection pathway.

References

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Key Takeaways

- Advanced CT requires faster, more precise contrast delivery.
- Higher-viscosity contrast increases injection resistance and pressure.
- Warming iodine-based contrast media to 37°C reduces viscosity to help facilitate high-flow rate injections.
- Warming isn't the whole equation: IV access, catheter size, contrast concentration, and patient factors also affect injection performance.
- Pressure-limited injections can reduce or interrupt contrast bolus.
- Traditional warming workflows require separate QA and manual processes; integrated technologies can streamline temperature maintenance and delivery.
- Syringeless technology can automate functions of contrast heat maintenance, monitoring, and delivery to reduce operator variability.



Scan to learn more about the CT motion syringeless injector