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Cold Contrast-Induced Coronary Slow Flow: A Preventable Pitfall in the Cath Lab

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Coronary slow flow (CSF) is an angiographic phenomenon characterized by delayed opacification of coronary arteries in the absence of significant obstruction. A definitive diagnosis is established only after excluding secondary causes, including no-reflow phenomenon, coronary embolism, ectatic arteries, and the use of exogenous vasoconstrictors. The reported prevalence of CSF ranges from 1% to 7% among individuals undergoing coronary angiography and is more common in young male smokers.[1] CSF is typically associated with recurrent angina at rest. Other clinical manifestations include acute coronary syndrome, ST-segment elevation myocardial infarction, ventricular arrhythmias, and sudden cardiac death, possibly due to increased QTc interval dispersion.[2,3]

Although CSF has been recognized by cardiologists for many years, it's pathogenic mechanisms remain incompletely understood. Proposed mechanisms include endothelial dysfunction, microvascular disease, and vasomotor abnormalities.[4] In clinical practice, CSF is often interpreted as angina with non-obstructive coronary arteries (ANOCA), leading clinicians to initiate antianginal therapy. However, our observations indicate that not all CSF represents true microvascular dysfunction; in some cases, it may result from modifiable procedural factors. Identifying and correcting these factors can prevent misclassification of patients as having ANOCA and avoid unnecessary long-term therapy.

We would like to highlight one overlooked and modifiable factor: the temperature of the contrast medium.

In our angiography unit, we recently observed numerous cases of CSF despite angiographically normal coronary arteries. Some patients developed chest pain, hypotension, or transient bradyarrhythmias, necessitating atropine infusion and even cardiopulmonary resuscitation. Although there was no coronary obstruction, these episodes were initially attributed to microvascular disease, and patients were subsequently started on therapies such as statins, beta-blockers, calcium channel blockers, and antiplatelet agents.

Upon investigation, we found that the contrast medium was routinely stored at room temperature (18 °C–20 °C) in the angiography laboratory, depending on air-conditioning conditions. Initially, we slightly warmed the contrast before use and observed a modest reduction in the incidence of slow-flow events. After warming the contrast to body temperature (36 °C–37 °C), the incidence of slow-flow events decreased markedly. Furthermore, the frequency of discomfort reactions—including palpitations, chest tightness, and chest pain—was significantly reduced. These findings suggest that optimal warming of contrast medium to body temperature is essential to minimize temperature-related vasomotor effects.

The observed phenomenon can be explained by the effects of cold contrast, which may provoke coronary vasoconstriction, increase blood viscosity, and impair microvascular perfusion, potentially leading to slow-flow events. Similar effects can occur with other fluids infused directly into the coronary circulation, including saline flushes and pharmacologic solutions. Rapid intra-coronary infusion of cold fluids can trigger thermal stimulation of vascular smooth muscle and endothelium, resulting in transient vasospasm, reduced microvascular compliance, and impaired coronary flow.

Roth et al.[5] reported that, increasing the contrast medium temperature from 20 °C to 37 °C significantly decreased its viscosity, which may also improve the quality of angiography when using small-diameter catheters. Additionally, the viscosity of contrast media strongly depends on the iodine concentration of the solution. Higher viscosity increases urinary viscosity, elevates tubular pressure, reduces urine flow, and decreases clearance. Together, these effects prolong the bioavailability of the contrast agent and may increase the risk of tubular injury.[6,7] Therefore, warming contrast media to body temperature may theoretically reduce both coronary and renal side effects.

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We recommend warming all intra-coronary infusions to body temperature prior to use as a safe, inexpensive, and effective preventive measure to reduce the risk of CSF. This principle extends beyond interventional cardiology; invasive radiologists performing intra-arterial procedures may also benefit from warming contrast in routine practice, minimizing vasospasm and improving procedural safety.

A review of the literature revealed only one study conducted in China that examined the effects of contrast media at different temperatures during coronary angiography, focusing on the relationship with adverse reactions.[8] In that study, a total of 1,044 patients were randomly assigned to receive either room-temperature or warmed contrast agents. The contrast agent used was Ioversol (Jiangsu Hengrui Medicine Co., Ltd.; 320 mg/mL). The incidence of discomfort reactions, including palpitations, chest tightness, and chest pain, was 9.68% in the room-temperature group and 4.40% in the warmed contrast group. Adverse reactions were significantly lower in the warmed group ($p < 0.01$). Differences in heart rate changes (n = 46 vs. n = 24, $p = 0.006$) and T-wave changes (n = 79 vs. n = 46, $p = 0.002$) between the groups were also statistically significant.

Further studies are warranted to examine the hemodynamic effects of fluid temperature. However, based on our experience, warming intra-arterial solutions to body temperature represents a simple and effective intervention with the potential to improve patient outcomes across multiple invasive specialties.

In conclusion, our observations indicate that contrast temperature is an important and modifiable factor contributing to CSF. Routine warming of contrast media and other intra-arterial solutions to body temperature is a simple, low-cost intervention that can reduce vasomotor reactions, prevent CSF events, improve procedural safety, and avoid unnecessary pharmacologic therapy. The use of specialized warming devices that maintain contrast media at body temperature could help standardize this preventive measure across catheterization laboratories.

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