Reduction in Contrast Induced Nephropathy from Coronary Invasive Procedures Using Ultra-Low Contrast Delivery Technique Based on Automatic Injector

Contrast induced nephropathy (CIN) is an iatrogenic renal injury due to intravascular contrast exposure. The incidence of CIN exceeds 15% with conventional angiographic techniques in patients with pre-existent chronic kidney disease (CKD) or cardiorenal syndrome.

We developed an ultra-low contrast delivery technique (ULCD) using an automated contrast injector system. A retrospective analysis was conducted in a total of 123 patients with CKD stage III or higher and who had undergone coronary angiography, percutaneous coronary intervention (PCI), or a combined procedure, using the ULCD technique from 2013 to 2014. The median contrast volume used was 17.9 mL (N=123). The study cohorts comprised diagnostic (15.2 ml; N=72), PCI (17.1 mL; N=30), and PCI and diagnostic groups (27.9 mL; N=21). The incidence of CIN observed in the entire cohort through day 7 was 3.3 % (4/123). Compared to data from literature, the ULCD technique delivers much less contrast per case and has lower CIN rates.

INTRODUCTION
CIN is associated with adverse clinical outcomes including prolonged hospitalization, potential progression to end-stage renal disease requiring dialysis, major adverse cardiovascular events, and higher mortality. The CIN is defined as >25 % relative increase or an absolute increase of >0.5 mg/dL in serum creatinine at 72 hours following contrast exposure. The risk of CIN is significantly higher in patients with CKD, diabetes, heart failure, and hemodynamic instability. CKD is probably the most significant risk factor for CIN development. Numerous therapies have been tested to avert CIN, but the only successful preventative strategies proven so far include appropriate hydration before contrast exposure, use of iso-osmolar/non-ionic contrast media, and contrast volume reduction. On this note, one study advocated contrast volume reduction such that its volume-to-creatinine clearance ratio is <3.7 [1,2].

ULCD STUDY
Our ultra-low contrast delivery technique (ULCD) was first implemented in 2006 at our institution (Sanford Cardiovascular Institute, Sanford School of Medicine at University of South Dakota, USA). It is a relatively simple and time-efficient technique that uses automated contrast injector system (ACIS) with feed-back programming. The aim of ULCD is to minimize contrast volume without sacrificing angiographic quality. The strategy...
to reduce the contrast volume starts before a procedure. If available, prior angiography can be used as “roadmap” especially in patients with bypass grafts or coronary artery anomalies. Selection of small size angiographic catheters can minimize contrast volume (at most 5 French catheters. Femoral access in our experience at least trends to lower contrast volumes, thus we prefer it in patients with CKD higher than III. Although in the literature there is no definite proof that femoral access results in lower contrast volumes delivered, in our experience it does make a difference, probably due to very low absolute contrast amounts used. We believe that classical catheters developed for femoral access due to ease of manipulation through groin make a positive difference. The catheters' coronary engagement is usually accomplished without any contrast delivered, just by observing their behavior on fluoroscopy and monitoring pressure wave tracings. Biplane camera with one injection for two standard diagnostic views is routinely used. No fewer than 15 frames per second cineography is used in ULCD for the sake of resolution. ACIS programming protocols are standardized for the left coronary artery and the right coronary artery [3].

Initially, a small-volume injection of 0.5 mL, referred to as the “spill over”, is used to assess coronary artery size (divided into large, average, and small) and flow (characterized as brisk or medium/slow flow). This information is used for ACIS initial programming. The left coronary artery system usually requires 2 contrast injections (4 standard runs). The right coronary artery usually requires a single injection (2 cine runs).

In our retrospective study, a total of 123 patients with CKD underwent either diagnostic, PCI, or PCI/diagnostic procedures during the study period. The median contrast volumes were lowest in diagnostic (15.2 mL; N=72), then in PCI (17.1 mL; N=30), and highest in diagnostic/PCI group (27.9 mL; N=21). Of these patients, none developed CIN within 72 hours of the procedure. Only 4 out of 123 patients (3.3%) had a CIN-defining increase in creatinine within 7 days. An additional 5 patients developed CIN by the end of week 3. The incidence of CIN during the total 30-day follow-up period was 7.3% (9 out of 123) [4].

**DISCUSSION**

Achieving euvoletic status before an invasive coronary procedure is a proven way to decrease CIN incidence; however, decreasing the volume of contrast administered is also a critical factor in achieving this goal. There is a surprising paucity of data in literature when it comes to contrast load reduction, especially if one takes into account the millions of coronary invasive procedures performed annually around the world. Decreasing the volume of contrast without sacrificing image quality seems somewhat unpopular and even embarrassing topic. Yet, recent MOZART trial confirmed that contrast limitation decreased he incidence of CIN development [5]. Contrast volume/creatinine clearance ratio can be an independent predictor for CIN development. The effort to minimize contrast volume during coronary invasive procedures must persist and persevere in the cardiology world. One recent meta-analysis suggests that ACIS use is associated with a 45 mL relative reduction in contrast volume and a 15 % decrease in incidence CIN compared with manual injection technique [6]. We developed a ULCD technique that uses significantly lower volumes (15-20 mL, although procedures using less than 10 mL of contrast are not unusual in our practice). The incidence of CIN seems also lower.

ULCD is a technique that comprehensively optimizes every step of an invasive coronary procedure to achieve lowering of the contrast volume. The prior angiogram (or its report) helps operator to understand the individual patient's coronary anatomy and road-map the guiding catheter engagement/guide wire manipulation with only fluoroscopy. The use of a biplane camera decreases contrast volume by half compared to a single plane camera. A guiding catheter telescopic extension (e.g. GuideLiner) that can deeply intubate a coronary artery can also serve as contrast limiting device in addition to its usual function of providing extra support. We use this device frequently for this purpose; injection volumes of 0.5 - 1 mL can be used to fully opacify the distal to its tip coronary circulation. However, our specific ACIS

![Figure 1. Left coronary angiography AC programming protocol (first injection). The first angiographic run settings depend on the visualization of the coronary upon filling the catheter with contrast. The settings are listed in the following order: volume (mL)/flow (mL/sec)/rise time (sec)/pressure (psi)](image-url)
programming is the key for successful contrast volume reduction in ULCD. We believe that standardized protocol of automatic injections can much more efficiently and accurately minimize contrast volume compared to manual injections. It also has the potential of being a safer and faster way of working in the cath lab.

As seen in every aspect of current technological advances, machines controlled by computers are an integral part of progress and eventually become indispensable. In our opinion this is going to be the fate of ACIS versus manual injections. Moreover, ULCD can be taught more easily since generally manual injections are not standardized and so are difficult to accurately communicate to trainees.

CONCLUSION
In conclusion, ULCD is a simple, efficient, reproducible technique that can be easily learned by cardiologists and catheterization laboratory technicians. We recommend its use at least in patients undergoing coronary invasive procedures, and at high risk for CIN.

REFERENCES
6. Minsinger KD, Kassis HM, Block CA, Sidhu M,