balance. In the control group, during the 25 ± 2-h treatment period, the cumulative saline hydration was 1,742 ± 290 ml. Importantly, however, urine output during hydration in the control group was 3,117 ± 876 ml. Thus, the control group had a net negative fluid balance. The reason for this finding is not entirely clear. It is possible that continuing the diuretics that both groups of patients were on as outpatients caused this finding. Forty-eight of 83 (58%) of patients in the control group were on diuretics, and there was no protocol to stop these medications before the intervention. Thus, the differences in the fluid administered and the fluid balance achieved likely influenced the results of the study in the 2 groups.

Majumdar et al. (2) in their meta-analysis comparing furosemide-based intervention with saline hydration for the prevention of CIN concluded furosemide-based interventions to be detrimental to saline hydration for the prevention of CIN. However, the studies that were analyzed did not have as rigorous a method of hydration in the intervention arms as did the study by Marenzi et al. (1).

In light of prior randomized controlled trials, to demonstrate benefit of furosemide-based intervention with hydration over saline hydration alone for the prevention of CIN, it is critical to keep both study arms equally hydrated. Failure to do so may influence the results of the study. Thus, studies maintaining equal hydration in both groups are needed to demonstrate a difference in outcome due to the intervention.

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REFERENCES

Reply

We appreciate the thoughtful comments of Drs. Chauhan and Sharma on our study. We agree with them with regard to the critical importance of generous hydration and positive fluid balance for contrast-induced nephropathy prevention. Current guidelines recommend administration of isotonic electrolyte solutions at an infusion rate of 1.0 ml/kg/h or less (0.5 ml/kg/h) in case of left ventricular ejection fraction <35% or New York Heart Association functional class >2 (1). We believe that this hydration rate represents a “safe” regimen conceived for avoiding fluid overload and pulmonary edema rather than an “effective” patient hydration. Indeed, a 70-ml/h hydration rate for 24 h in a 70 kg fasting patient is the minimal fluid volume needed to avoid dehydration. By contrast, vigorous hydration before coronary procedures is difficult logistically and poorly tolerated, in particular in the presence of impaired cardiac and renal function. Thus, despite general agreement on hydration benefit and strong recommendation of all guidelines, most patients are not sufficiently hydrated in routine clinical practice.

In our study (2), saline infusion and urine output were rigorously measured. However, from these data it is not possible to extrapolate the net fluid balance, because all patients were encouraged to freely drink water after coronary angiography. Thus, it is likely that the control group too had a modestly positive or, at worst, a slightly negative fluid balance.

Although further studies are needed to elucidate the mechanisms of the innovative preventive treatment described in our report, it is unlikely that its beneficial effects might be explained by the initial 250-ml saline bolus only. We believe that simultaneous high urine-flow rate resulting from furosemide administration together with dehydration prevention obtained by exactly matching saline infusion might have played an important role in the results observed in the treated patients. Indeed, preclinical studies demonstrated that prolonged contact time of contrast with the tubular epithelial cells is associated with a greater tubular damage, as indicated by biomarkers (3), and that high urine-flow rates flush the renal tubules and lower contrast concentration in tubular fluid. This accelerates contrast excretion, thus reducing the exposure time of tubular cells. Therefore, the high urine-flow rate achievable with this innovative treatment might lower contrast concentration and viscosity and accelerate contrast excretion, thus reducing the exposure time of tubular cells to its toxicity (4).

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REFERENCES
Quality Control and the Learning Curve of Transcatheter Aortic Valve Implantation

With the introduction of transcatheter valves, the cardiologists and cardiac surgeons have been faced with a new challenge, that is, to keep efficacy and safety competitive in relation to conventional surgery while implementing a new therapeutic strategy that requires the acquisition of new skills and the close cooperation between different specialties. In this complex scenario, the strict monitoring of the overall and individual performance appears mandatory. The paper by Alli et al. (1), recently published in JACC: Cardiovascular Interventions, represents a commendable attempt to characterize the learning curve of transcatheter aortic valve implantation (TAVI) in terms of number of procedures needed to become proficient with this technique, and to gain insight into the steps that are critical for the successful initiation of a TAVI program.

The paper by Alli et al. (1), however, is based on the retrospective analysis of outcome data arbitrarily divided into tertiles. This rather traditional approach takes an average performance over time; it may hide clusters of failure and may limit our understanding of the learning process. A more appropriate statistical tool, in our opinion, would be represented by time series analysis, and specifically by the cumulative sum (CUSUM) analysis. These methods report graphs of changes in outcome rates over time, and allow for the real-time monitoring of the individual and team performance, representing a particularly promising tool for monitoring learning effect and performance (2).

During the last decade at our institution, there has been a dramatic shift toward minimally invasive approaches for mitral and aortic valve surgery. The CUSUM analysis has been routinely used to monitor the performance of the surgeons introduced to this new technique with excellent results (3,4). It was, therefore, natural to employ this methodology to assess the performance of the TAVI team. It is interesting to observe that, similar to what was reported by Alli et al. (1), the analysis of our first 70 patients showed that “proficiency” was obtained after performing about 30 cases. In particular, the lower boundary line (the line on the CUSUM chart indicating a complication rate equal or inferior to the “accepted failure rate”), was crossed at Patient #29.

The real strength of the CUSUM charts is that they allow one to identify easily and quickly the ongoing trend. If the trend suggests that the procedure is going out of control, the monitored process can be analyzed in detail, and the right countermeasures can be instituted. The failure of a TAVI procedure may be due to several factors, many of which are not directly related to the operative technique itself: by allowing the early identification of negative trends, the CUSUM charts may prompt internal audits aimed to the identification of the causes of failure, helping to take the procedure back into control (2).

With the growing rate at which new techniques and technologies are introduced in cardiac surgery and interventional cardiology, quality control will become a key issue in the near future. For this reason Alli et al. (1) deserve merit for their pioneering paper. However, we believe that time series analysis could be an excellent means to analyze the performance of the TAVI teams, and we would strongly suggest adopting this methodology to monitor the learning curve for TAVI.

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REFERENCES

Reply

We thank Dr. Cerillo and colleagues for their thoughtful and insightful comments on our paper (1). In their letter, they have highlighted the benefit of using time series analysis to assess learning curve and quality control, and we generally agree with their comments. The traditional method of assessing surgical results is the retrospective analysis of outcome data as used in our study. Statistical testing in this regard is an appropriate way of assessing the learning curve when the interest is in determining whether or not a difference has reached a magnitude of statistical