Acute Hyperglycemia Facilitates Contrast-Induced Nephropathy: Independent Risk Marker in STEMI Patients Undergoing Primary Percutaneous Coronary Intervention

Editorial

Diagnostic and therapeutic interventional procedures using iodinated radiographic contrast media may cause a relatively common complication called contrast-induced nephropathy (CIN) [1-4]. CIN has a worse prognosis than acute renal failure not related to contrast media. CIN is the third most common cause of acute renal failure in hospitalized patients and it is associated with high short- and long-term morbidity and mortality [5-12]. CIN is defined as an increase in the serum creatinine level beginning within the first 24 h after contrast exposure and peaking in most patients up to 5 days after exposure (3-6). Most definitions have required a 0.5 to 1.0 mg/dl increase in the serum creatinine level and/or a rise in the serum creatinine level to 25% to 50% above baseline [1-5]. However, the Acute Kidney Injury Network has defined it as a rise in the serum creatinine level equal to or greater than 0.3 mg/dl or an increase in the serum creatinine level of 50% or more from baseline [3].

The pathophysiology of CIN in acute hyperglycemia is poorly understood. Decreased glomerular filtration rate at baseline appears to be very important for its development. Two main factors are paramount, renal vasoconstriction and tubular injury [3-5]. Renal vasoconstriction is mediated by adenosine, endothelin, the high osmolality of some contrast agents, and blockade of endogenous vasodilators such as nitric oxide and local prostaglandins. Renal blood flow decreases up to 30% 2 h after contrast exposure and decreases up to 50% after 4 h. The association of volume depletion with reduced renal blood flow leads to increased viscosity, which predisposes to renal medullary hypoxia and ischemia [3-6]. Acute hyperglycemia may worsen this ischemic process since it may induce osmotic diuresis, resulting in volume depletion and dehydration and further increasing CIN risk and severity. This process may be facilitated by interstitial edema and may lead to loss of renal tubular cells. On the other hand, tubular injury is thought to result from a direct cytotoxic effect of iodinated contrast media, probably mediated by oxidative stress and the generation of reactive oxygen species. Stasis of contrast media in renal tubules may contribute to this phenomenon [3-6].

The prevalence of CIN depends in part on a variety of patient-related and procedure-related factors [1]. The most important patient-related risk factor is pre-existing impairment of renal function. An estimated glomerular filtration rate of less than 60 ml/min/1.73 m2 may be accompanied with impaired renal vasodilation and reduced clearance of contrast media. These factors may facilitate the hemodynamic changes leading to decreased renal blood flow and tubular toxicity associated with use of these iodinated agents [8-14]. The presence of diabetes mellitus is a risk marker for developing CIN, especially in the case of diabetic nephropathy. Advanced aging also appears to be a risk factor for CIN. In addition, congestive heart failure and reduced left ventricular ejection fraction have been shown to be independent predictors of CIN, possibly related to impaired renal vasodilation [14]. Anemia, cirrhosis, and other hypovolemic entities characterized by low effective intravascular volume have also been identified as indicators of CIN [15]. Nephrotoxic drugs increase the sensitivity of the kidney to iodinated contrast media [15].

On the other hand, procedure-related risk markers for CIN include the use of high-osmolar ionic contrast media, low-osmolar contrast media (compared with nonionic iso-osmolar contrast media), high volumes of contrast media, and multiple procedures requiring contrast media within 72 h [3-6]. Percutaneous coronary intervention (PCI) or peripheral artery intervention, coronary artery bypass surgery, and use of an intra-aortic balloon pump represent additional procedure-related risk markers [12-18]. The study of Khorsheid H et al. [17] in this issue of the Journal of Cardiology and Current Research investigated the association between admission acute hyperglycemia and the risk of subsequent (CIN) in patients with STEMI undergoing primary PCI. The authors studied 120 patients who presented with acute STEMI and were treated with primary PCI.

They divided their patients into 2 groups: Group A included 60 patients with acute hyperglycemia (blood glucose >198 mg/dl),
Acute hyperglycemia is known to be associated with several mechanisms and adverse effects that contribute to poor outcome in patients with acute myocardial infarction. These mechanisms include increased oxidative stress, increased cytokine activation, prothrombotic effects, enhanced platelet activation, inflammatory response, endothelial dysfunction and impaired microcirculatory function as manifested by post-PCI no-reflow and impaired ischemic preconditioning [19-26]. Several studies have demonstrated that acute hyperglycemia, regardless of the diabetic state, is a powerful predictor of mortality, larger infarct size and increased risk of cardiovascular complications in patients with myocardial infarction [27-34]. Stranders I et al. [33] demonstrated that for every 18-mg/dL increase in glucose level, there is a 4% increase in mortality in non-diabetic patients presenting with myocardial infarction [33].

We agree with Khorshid H et al. [17] in their assumption that being admission glucose level measurement readily available for all patients presenting with STEMI, this variable could be incorporated into risk calculation models for identification of patients at risk for development of CIN after primary PCI. On the other hand, it is relevant and necessary to further investigate if admission hyperglycemia serves as a risk marker for CIN in patients out of the context of acute coronary syndrome who receive iohodinated contrast media during diagnostic coronary angiography.

References

1. Rihal C, Tector SC, Grill DE, Berger PB, Ting HH, et al. (2002) Incidence and prognostic importance of acute renal failure after percutaneous coronary intervention. Circulation 105(19): 2259-2264.
2. Pak S, Vatsynovich Y, Markovic JP (2017) Correlation between admission hyperglycemia and area at risk and infarct size quantified by CMR in acute myocardial infarction. Hell. J Cardiol pii: S109-9666(17)30222-2.
3. McCullough PA (2008) Contrast-induced acute kidney injury. J Am Coll Cardiol 51(15): 1419-1428.
4. Rudnick M, Feldman H (2008) Contrast-induced nephropathy: what are the clinical consequences? Clin J Am Soc Nephrol 3(1): 263-272.
5. Nie S, Tang L, Zhang W, Feng Z, Chen X (2017) Are there modifiable risk factors to improve AKI? BioMed Research International.
6. Gleeson TG, Buahugabapitya S (2004) Contrast-induced nephropathy. Am J Radiol 183(6): 1673-1689.
7. Dangas G, Iakovou I, Nikolovy E, Aymong ED, Mintz GS, et al. (2005) Contrast-induced nephropathy after percutaneous coronary interventions in relation to chronic kidney disease and hemodynamic variables. Am J Cardiol 95(1): 13-19.
8. Gruberg L, Mintz GS, Mehran R, Gangas G, Lansky AJ, et al. (2000) The prognostic implications of further renal function deterioration within 48 hours of interventional coronary procedures in patients with pre-existing chronic renal insufficiency. J Am Coll Cardiol 36(5): 1542-1548.
9. Gruberg L, Mehran R, Dangas G, Mintz GS, Waksman R, et al. (2001) Acute renal failure requiring dialysis after percutaneous coronary interventions. Catheter Cardiovasc Interv 52(4): 409-416.
10. Marenzi G, Lauri G, Assanelli E, Campodonico J, De Metrio M, et al. (2004) Contrast-induced nephropathy in patients undergoing primary angioplasty for acute myocardial infarction. J Am Coll Cardiol 44(9): 1780-1785.

11. Marenzi G, Assanelli E, Campodonico J, Lauri G, Marana I, et al. (2009) Contrast volume during primary percutaneous coronary intervention and subsequent contrast-induced nephropathy and mortality. Ann Intern Med 150(3): 170-177.

12. Sadeghi HM, Stone GW, Grines CL, Mehran R, Dixon SR, et al. (2003) Impact of renal insufficiency in patients undergoing primary angioplasty for acute myocardial infarction. Circulation 108(22): 2769-2775.

13. McCullough PA, Sandberg KR (2003) Epidemiology of contrast-induced nephropathy. Rev Cardiovasc Med 4 Suppl: 53-59.

14. Mehran R, Aymong EG, Nikolosky E, Lasic Z, Iakovou I, et al. (2004) A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention. Development and initial validation. J Am Coll Cardiol 44(7): 1393-1399.

15. Toprak O, Cirit M, Vesil M, Byrne DW, Postaci N, et al. (2006) Metabolic syndrome as a risk factor for contrast-induced nephropathy in non-diabetic elderly patients with renal impairment. Kidney Blood Press Res 29(1): 2-9.

16. Stroker JM, McCullough PA, Rao S, Inzucchi SE, Spertus JA, et al. (2010) Pre-procedural glucose levels and the risk for contrast-induced acute kidney injury in patients undergoing coronary angiography. J Am Coll Cardiol 55(14): 1433-1440.

17. Khorshid H, Gomaa Y, Tamara A, Gomaa E (2017) Acute hyperglycemia an independent risk factor for contrast-induced nephropathy in patients undergoing primary percutaneous coronary intervention for STEMI. Cantiolli Curr Res 9(6): 00346. DOI: 10.15406/jccr.2017.09.00346.

18. Hafidh SAS, Reuter MD, Chassels LJ, Aradhyula S, Bhutto SS, et al. (2007) Effect of intravenous insulin therapy on clinical outcomes in critically ill patients. Am J Med Sci 333(6): 354-361.

19. Finn WF (2006) The clinical and renal consequences of contrast-induced nephropathy. Nephrol Dial Transplant 21(6): 12-110.

20. Nakamura T, Ako J, Kadokawa T, Funayama H, Sugawara Y, et al. (2009) Impact of acute hyperglycemia during primary stent implantation in patients with STElevation myocardial infarction. J Cardiol 53(2): 272-277.

21. Ishihara M, Kojima S, Sakamoto T, Asada Y, Tei C, et al. (2005) Acute myocardial infarction is associated with adverse outcome after acute myocardial infarction in the coronary intervention era. Am Heart J 150(4): 814-820.

22. Timmer JR, Ottervanger JP, de Boer MJ, Dambrik JH, Hoornje JC, et al. (2005) Hyperglycemia is an important predictor of impaired coronary flow before reperfusion therapy in ST-segment elevation myocardial infarction. J Am Coll Cardiol 45(7): 999-1002.

23. Yang Z, Laubach VE, French BA, Kron IL (2009) Acute hyperglycemia oxidative stress and exacerbates myocardial infarction by activating nicotinamide adenine dinucleotide phosphate oxidase during reperfusion. J Thorac Cardiovasc Surg 137(3): 723-729.

24. Undar A, Wiek I, Stefiene E, Zmutah K, Tracz W (2008) Hyperglycemia is associated with enhanced thrombin formation, platelet activation, and fibrin clot resistance to lysis in patients with acute coronary syndrome. Diabetes Care 31(8): 1590-1595.

25. Geiser T, Muller K, Aichele S, Bigalke B, Stellos K, et al. (2010) Impact of inflammatory state and metabolic control on responsiveness to dual antiplatelet therapy in type 2 diabetes after PCI: Prognostic relevance of residual platelet aggregability in diabetes undergoing coronary interventions. Clin Res Cardiol 99(11): 743-752.

26. Hartege M, Unger T, Kintscher U (2007) The endothelium and vascular inflammation in diabetes. Diab Vasc Dis Res 4(2): 84-88.

27. Worlthy MI, Holmes AS, Willoughby SR, Kucia AM, Hershztyn T, et al. (2007) The deleterious effects of hyperglycemia on platelet function in diabetic patients with acute coronary syndromes. Mediation by superoxide production, resolution with intensive insulin administration. J Am Coll Cardiol 49(3): 304-310.

28. Ceriello A, Giacomello R, Stel G, Motz E, Taboga C, et al. (1995) Hyperglycemia-induced thrombin formation in diabetes. The possible role of oxidative stress. Diabetes 44(8): 924-928.

29. Kawano H, Motoyama T, Hirashima O, Hishi N, Miyao Y, et al. (1999) Hyperglycemia rapidly suppresses flow-mediated endothelium-dependent vasodilation of brachial artery. J Am Coll Cardiol 34(1): 146-154.

30. Sakamoto T, Ogawa H, Kawano H, Hishi N, Miyamoto S, et al. (2000) Rapid change of platelet aggregability in acute hyperglycemia. Detection by a novel laser-light scattering method. Thromb Haemost 83(3): 475-479.

31. Monteiro S, Monteiro P, Goncalves F, Freitas M, Providência LA (2010) Hyperglycemia at admission in acute coronary syndrome patients: prognostic value in diabetics and non-diabetics. Eur J Cardiovascular Prev Rehabil 17(2): 155-159.

32. Chen PC, Chua SK, Hung HF, Huang CY, Lin CM, et al. (2014) Admission hyperglycemia predicts poorer short- and long-term outcomes after primary percutaneous coronary intervention for STElevation myocardial infarction. J Diabetes Investig 5(1): 80-86.

33. Stranders I, Diamant M, van Gelder RE, Spruijt HJ, Twisk JW, et al. (2004) Admission blood glucose level as risk indicator of death after myocardial infarction in patients with and without diabetes mellitus. Arch Intern Med 164(9): 982-988.

34. Kosisborod M, Rathore SS, Inzucchi SE, Masoudi FA, Wang Y, et al. (2005) Admission glucose and mortality in elderly patients hospitalized with acute myocardial infarction: implications for patients with and without recognized diabetes. Circulation 111(23): 3078-3086.