Feature

Using the Mehran Risk Scoring Tool to Predict Risk for Contrast Medium–Induced Nephropathy in Patients Undergoing Percutaneous Angiography

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BACKGROUND Patients who have radiological imaging with contrast material are at risk for contrast medium–induced nephropathy, reduced renal function, longer hospitalizations, and renal failure requiring dialysis.

OBJECTIVE To determine whether the Mehran risk scoring tool can be used to predict changes in hospitalized patients who had percutaneous angiography.

METHODS Data on 196 patients admitted for cardiac angiography who had Mehran risk scores higher than 6 were analyzed retrospectively. Creatinine levels, used as predictors of contrast medium–induced nephropathy, were evaluated at day 2, day 3, and day 4 through day 7.

RESULTS Creatinine levels were significantly higher in patients with a Mehran risk score of 11 or higher than in patients with a risk score of 6 to 10 at all times.

CONCLUSIONS The Mehran risk scoring tool provides reliable data before patients have percutaneous angiography. (*Critical Care Nurse*. 2011;31[1]:e17-e22)

Patients who have radiological imaging with contrast material are at risk for contrast medium–induced nephropathy (CIN). This abnormality is due to toxic ischemic injury of the kidney associated with decreased medullary blood flow and oxygen tension after exposure to contrast medium and the subsequent secretion of vasoconstrictive hormones.[1] CIN is defined as an increase in the serum creatinine level of 25% or more or an absolute increase of 0.5 mg/dL or more (to convert to micromoles per liter, multiply by 88.4) from baseline level that occurs 48 to 72 hours after exposure to contrast medium.[2] CIN is the third leading cause of acute kidney injury in hospitalized patients,[3] accounting for up to 11% of iatrogenic renal insufficiency.[4,5] Older patients and patients with preexisting renal failure, diabetes mellitus, decreased left ventricular ejection fraction, or unstable hemodynamic status are particularly at risk for CIN when undergoing cardiac studies.[6,7] CIN has been associated with increased in-hospital morbidity and mortality and with long, costly hospital stays.[6]

Reliable risk assessment before percutaneous coronary interventions (PCIs) and subsequent implementation of appropriate prophylactic regimens are vital.[6] Various prophylactic

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measures and tools to predict the risk for CIN have been described, but no consensus exists about which measures or tools are most effective.[8] Not all risk scoring methods use a rating system that weighs the cumulative effect of each CIN risk factor, are user friendly or based on easily obtained clinical measures, and evaluate the same variables. A reliable and clinically convenient risk scoring tool is needed. Risk profiles and scores differ substantially between patients, depending on the number and relevance of individual clinical factors.[9] When clinical risk factors are identified before PCI and an overall risk level is determined, relevant interventions to minimize kidney damage can be implemented.

We reviewed the literature to compare existing scoring tools used to determine the risk for CIN. We selected the most comprehensive, well-tested, and user-friendly tool, the validated Mehran risk scoring tool, for our study. We used a retrospective chart review to determine whether the scores were predictive of changes in creatinine level after cardiac angiography in hospitalized patients who were at low (Mehran score, 6-10) and high (Mehran score, >11) risk for CIN.

Background

A variety of studies have been conducted to develop and evaluate the effectiveness of scoring tools to determine the risk for CIN. In 2004, Mehran et al[10] compared 4989 patients with a control group of 2786 patients to determine if a factor-weighted risk classification system could be developed to predict risk for CIN after PCIs. Patients who had been treated for shock and acute myocardial infarction were excluded from the study. Factors included in determining the risk score were (1) arterial hypotension with systolic blood pressure less than 80 mm Hg for at least 1 hour and requiring inotropic support with medications, (2) use of an intra-aortic balloon pump (IABP) within 24 hours of the coronary intervention, (3) congestive heart failure class III/IV according to the New York Heart Association classification, (4) history of pulmonary edema, (5) chronic kidney disease, (6) diabetes mellitus, (7) age greater than 75 years, (8) anemia (hematocrit <39% for men and <36% for women), (9) volume of contrast medium, and (10) serum level of creatinine greater than 1.5 mg/dL or an estimated glomerular filtration rate (GFR) less than 60 mL/min per 1.73 m^2. No differences were found when creatinine clearance and serum creatinine concentration were used as predictors of CIN. The Mehran tool is available in graphic form, making the tool easy for clinicians to use.

Barthelomew et al[11] used a cohort of 20 479 patients who had PCI to derive the William Beaumont Hospital (WBH) CIN risk score. Weighted score variables were based on a creatinine clearance of 60 mL/min or less (score, 2), urgent PCI (score, 2), IABP use (score, 2), diabetes mellitus (score, 1), congestive heart failure (score, 1), hypertension (score, 1), peripheral vascular disease (score, 1), and volume of contrast medium greater than 260 mL (score, 1). In 2007, Skelding et al[8] validated the WBH risk score by examining data on 4814 PCI procedures at the Mayo Clinic. The results indicated that the WBH risk score could be used to detect patients at high and low risk for CIN and to direct the use of preventive measures that improved patients' prognoses. A limitation of the study by Skelding et al was the number of missing risk factors, from 13% for serum levels of creatinine to 25% for other risk factors. In addition, the lack of a graphic presentation of the WBH tool makes the tool more difficult to use.

In 2007, Bouzas-Mosquera et al[12] evaluated 315 patients who underwent emergent cardiac catheterization and used the data to develop a scoring tool to predict acute renal failure. The investigators then validated the tool in a second cohort

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of 287 patients who received low-osmolality contrast medium (iohexol) along with hydration, depending on the preference of the treating physician. In the risk score/classification, 3 points were assigned for cardiogenic shock at admission and 2 points each for other risk factors such as diabetes mellitus, time to reperfusion greater than 6 hours, anterior myocardial infarction, and baseline serum creatinine and urea levels. The total score was the sum of all values. A significant risk for acute renal failure was associated with increased scores. The risk was 12.5% for scores of 4 to 5, 46.2% for scores of 6 to 7, and 66.7% for scores of 8 or higher. After 1.3 years, acute renal failure was a powerful predictor of mortality, cardiovascular death, and reinfarction. A limitation of the study was that the measurements of serum creatinine concentrations were completed at 2 different hospitals.

Herts et al[13] reviewed the charts of 5138 outpatients who underwent computed tomography and used estimated GFR to identify patients at risk for CIN. The number of patients who had had the imaging procedure without receiving contrast material was not clear. Data were collected on patients' age, sex, and race, and serum levels of urea nitrogen, albumin, and creatinine were measured 6 months before and 6 months after the imaging. The 4-variable modification of diet in renal disease (MDRD) equation was used to calculate GFR. A higher number of outpatients scheduled for contrast medium–enhanced computed tomography met the criteria for renal insufficiency and were at increased risk for CIN when the MDRD equation was used than when elevated creatinine levels were used to estimate risk. Herts et al[13] acknowledged that GFR is difficult to calculate in a clinical setting because the calculation requires multiple factors with negative exponents within a complex formula. In addition, the MDRD equation is not accurate for hospitalized patients who are acutely ill. Therefore, we did not use GFR calculated by using the MDRD equation as a screening tool to determine the risk for CIN.

In 2008, Nyman et al[6] studied the dose of contrast medium, estimated GFR calculated by using the Cockcroft-Gault equation, and CIN risk factors in 391 Swedish patients. Independent predictors of CIN were dose of contrast medium, estimated GFR, left ventricular ejection fraction, and cardiogenic shock. The investigators concluded that relating the dose of contrast medium to estimated GFR is a good way to assess CIN risk. A limitation of the study was that only 20% of the study participants were women. In addition, the effects of dehydration, anemia, and nephrotoxic drugs were not evaluated. Nyman et al admitted that their risk scoring process was complicated enough to require a Microsoft Excel spreadsheet that considers the concentration of contrast medium, estimated GFR, left ventricular ejection fraction, and presence or absence of shock and requires calculations available at http://www.arwen.se/radiology. Use of such a formula is more appropriate for physicians or radiologists than for nurses because it yields volumes of contrast medium; it is not a simple screening tool that can be used by nurses to predict risk.

In 2009, Ghani and Tohamy[1] studied 247 patients (development data set) and 100 control patients (validation data set) in Kuwait who had been admitted for PCI. Risk scores were assigned on the basis of 5 variables: renal impairment before the PCI, diabetes mellitus, presence of shock, female sex, and multivessel PCI. Assigned scores were 7 for baseline serum creatinine level greater than 115 µmol/L; 3 for shock; and 2 each for female sex, multivessel PCI, and diabetes mellitus. All patients in the study were given dextrose half normal saline with sodium bicarbonate for 4 hours before and 24 hours after the PCI. Ghani and Tohamy acknowledged the need for additional validation in larger, multicenter trials and greater participation of women before the risk scoring tool is ready for clinical use.

Maioli et al[14] described the development of a simplified risk scoring system based on clinical characteristics present before elective coronary angiography and PCI that are predictive of CIN. They examined records of 1218 Italian patients and found 7 markers with weighted scores that were predictive of CIN. Scores were 1 for age at least 73 years; 2 each for diabetes mellitus, left ventricular ejection fraction of 45% or less, baseline serum creatinine level at least 1.5 mg/dL, baseline creatinine clearance 44 mL/min or less, and creatinine level after hydration greater than or equal to the level before hydration; and 3 for any procedure with contrast material performed within the preceding 72 hours. The risk score developed could be used to predict which patients were at high and low risk for CIN after coronary intervention.

In 2010, Aguiar-Souto et al[4] published a retrospective analysis of 227 PCI patients, the majority of whom were at low risk for CIN according to scores determined by using the Mehran tool. The results indicated that volume of contrast medium, Mehran risk score, and estimated GRF calculated by using the MDRD or Cockroft equations were not predictive of CIN after PCI. Limitations of the study were inclusion of patients who were undergoing elective procedures, substantial hydration for each patient, correction of anemia before the procedure, elimination of nephrotoxic drugs, the length of the procedure (2 hours) and the short half-life of the contrast medium used, the relatively young age of patients (mean, 64 years), inclusion of patients with a low incidence of diabetes mellitus and renal insufficiency, injection of contrast medium in the collateral branches only to minimize changes in blood flow in the renal artery, and an unbalanced prevalence of patients across the different categories of risk. These factors limited the applicability of the study for many inpatient populations.

Table 1 Calculation of Mehran risk score

Risk factor	Mehran risk score[10]
Arterial hypotension for systolic blood pressure <80 mm Hg for at least 1 hour requiring inotropic support with medications	5
Use of an intra-aortic balloon pump within 24 hours of the procedure	5
Congestive heart failure rated class III/IV on the New York Heart Association classification	5
Documented history of pulmonary edema	5
Documented history of chronic kidney disease	5
Patient's age >75 years	4
Documented anemia (hematocrit <39% for men and <36% for women)	3
Documented history of diabetes	3
Volume of contrast material used	1 for each 100 mL
Preprocedural serum level of creatinine >1.5 mg/dL[a]	4
or An estimated glomerular filtration rate <60/mL/min per 1.73 m^2	2 for 40-60 4 for 20-40 6 for <20

[a] To convert to micromoles per liter, multiply by 88.4.

Methods

Because risk factors for CIN in individual patients occur in combination, the use of cumulative, weighted risk scoring is important. The Mehran risk scoring tool was selected for use in this study because of the large number of patients used in developing and validating the tool, the cumulative nature of risk assessments based on weighted integers, and inclusion of a large number of patient-related (age >75 years, diabetes mellitus, congestive heart failure, admission for pulmonary edema, hypotension, anemia, and chronic kidney disease) and procedure-related (use of IABP or increasing volumes of contrast medium) variables. The Mehran tool fits nicely on a single page and can easily be completed by a critical care nurse using available clinical information, which can then be shared with treating physicians and other providers if the risk score is high.

After it was verified that the study was exempt from review and permission was obtained to use the Mehran risk scoring tool,[10] retrospective data were collected from 2000 electronic medical records of patients admitted to an academic medical center for cardiac angiography during a 1-year period. Of those 2000 patients, 196 had Mehran risk scores of 6 or greater. Data on these 196 patients were collected for analysis. Patients who died before the chart reviews were completed, those treated with dialysis, and those lost to follow-up were excluded from the study. No identifying information was collected during review of the medical records. Finally, a cumulative risk score was calculated (Table 1).

The serum creatinine and hematocrit levels determined most recently before the PCI were considered baseline. At the facility where the study was done, normal serum creatinine levels are 0.6 to 1.2 mg/dL in men and 0.5 to 1.1 mg/dL in women. Creatinine values after the PCI were determined on days 2, 3, and 4 through 7. Patients undergoing percutaneous angiography were not transferred from another hospital. Patients in the study had not previously received contrast medium at another facility within the preceding month. When a patient's Mehran risk score was greater than 6, the patient's data

Table 2 Types of prophylaxis and hydration used

Type of prophylactic or hydration	No. of patients	% of sample
Acetylcysteine alone	7	4
Acetylcysteine with bicarbonate	51	26
Bicarbonate alone	55	28
Normal saline	83	42

were entered into Microsoft Excel spreadsheets and were checked for accuracy by double entry for 50% of the data. Prophylaxis and hydration (Table 2) were according to physician preference (not hospital policy).

All patients had use of metformin (Glucophage) and diuretics discontinued from 24 hours before to 48 hours after administration of contrast medium. If congestive heart failure was acute enough to diminish a patient's ability to breathe, furosemide (Lasix) was given per physician order. Angiotensin-converting enzyme (ACE) inhibitors were given, and hydralizine (10-20 mg intravenously) was given to patients with systolic blood pressure greater than 160 mm/Hg. Hydralazine was given because it is fast acting and lowers blood pressure quickly so that bleeding is diminished before the artery is punctured during cardiac catheterization.[15] Because the study was retrospective, medication use was according to the prescribing preferences of individual physicians irrespective of the controversial role of ACE inhibitors in the development of CIN. Some investigators have reported that ACE inhibitors can prevent CIN in patients with diabetes mellitus[16] or chronic kidney disease,[17] and other researchers[18,19] have recommended that administration of ACE inhibitors be discontinued before cardiac catheterization.

Patients were divided into moderate-risk (risk score, 6-10) and high-risk (risk score, ≥11) groups for CIN to determine if creatinine levels differed significantly between the groups on different measurement days. SPSS, version 17.0 (SPSS Inc, Chicago, Illinois), was used for *t* tests for independent samples.

Results

Demographic data, including age and ethnic/racial background for the 196 patients with a Mehran risk score greater than 6 are summarized in Table 3.

A total of 67% of the sample were men and 33% were women. Among the 196 patients, 97 (49.5%) had a history of diabetes mellitus, 62 (31.6%) had a history of congestive failure, and 12 (6.1%) had been treated with an IABP.

Patients with a risk score of 11 or greater had significantly higher creatinine levels than did patients with creatinine levels of 10 or less on measurement days 2 and 3. On days 4 through 7, with equal variances not assumed, patients in the high-risk group had significantly higher creatinine levels than did patients in the low-risk group (Table 4).

Table 3 Demographic data on patients' age and ethnic/racial background

Variable	No. of patients	%[a]
Age, y[b]		
20-40	2	1
41-50	2	1
51-60	22	11
61-70	27	14
71-80	80	41
81-90	52	27
91-100	10	5
Ethnic origin/racial background		
White	138	70
Hispanic	13	7
African American	16	8
Southeast Asian	9	5
Pakistani	7	4
Ukrainian	4	2
Fijian	9	5

[a] Because of rounding, not all percentages total 100.
[b] One patient declined to give her age.

Discussion

Our study, like that of Aguiar-Souto et al,[4] was retrospective. In our study, hydration and prophylaxis had already been administered according to physician preference before the Mehran risk score was calculated. We found that Mehran scores were effective in predicting increases in creatinine level. In contrast, Aguiar-Souto et al,[4] who evaluated the Mehran risk scoring tool and several other methods of evaluating the risk for CIN, reported that

Table 4 Results

Day	Mean creatinine level, mg/dL[a]	*t*	Degrees of freedom	*P*
2	1.23 for risk score ≤10 1.70 for for risk score ≥11	2.46	84	.02
3	1.33 for for risk score ≤10 1.86 for risk score ≥11	2.98	60	.01
4-7	1.33 for for risk score ≤10 2.08 for risk score ≥11	4.65	62.65	<.001

[a] To convert to micromoles per liter, multiply by 88.4.

predictive risk scoring was not effective. In their study,[4] risk scoring methods might not have provided scores predictive of CIN because younger patients without a history of diabetes mellitus or renal insufficiency were included in the study sample. Aguiar-Souto et al also corrected anemia, eliminated nephrotoxic drugs, and used substantial hydration or prophylaxis before the start of procedures that required contrast medium, thus eliminating most risk factors for CIN before the study began.

Implications

Experienced nurses working in academic medical centers can play a key role in assessing a patient's risk for CIN and in collaborating with physicians or other medical providers to ensure that nephrotoxic medications are discontinued 24 hours before relevant procedures. Experienced nurses are also responsible for advocating for safe amounts and types of prophylaxis and hydration for patients who are at moderate to high risk for CIN and for ensuring that serum creatinine levels are measured for 2 to 7 days after the radiological procedure.

We found that the Mehran risk scoring tool was a comprehensive, user-friendly method of evaluating a patient's risk for CIN before procedures that require use of contrast medium. The tool is now being used by nurses 2 days before scheduled radiological studies that require contrast medium to assess patients' risk. Nurses inform physicians or other medical providers of the risk score and collaborate to ensure that interventions to prevent CIN are implemented. The Mehran tool could also be incorporated into the electronic medical record to ensure consistency of its use before radiological procedures that include contrast medium.

Limitations

This retrospective study was limited by the different methods for pretreatment and hydration used by physicians before the Mehran risk score was calculated.

Other limitations of the study included the 67% preponderance of men in the sample and collection of data from a single academic medical center. In addition, times when blood samples were obtained and degree of outpatient compliance for follow-up measurement of creatinine levels for discharged patients were inconsistent. Finally, we had no information about the location of the IABP in the aorta, including whether the insertion site of the pump was low enough to compromise blood flow to the renal arteries simply because of the location of the site. CCN

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Financial Disclosures
None reported.

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