CARDIOVASCULAR MEDICINE

Assessment of cardiac risk before non-cardiac surgery: brain natriuretic peptide in 1590 patients

J Dernellis, M Panaretou

Heart 2006;92:1645-1650. doi: 10.1136/hrt.2005.085530

See end of article for authors' affiliations

Correspondence to:
Dr John Dernellis, 1
Kathigitou Karakatsani St,
811 00 Mytilini, Greece;
dernellis@yahoo.gr

Accepted 11 May 2006
Published Online First
18 May 2006

Objective: To evaluate the predictive value of brain natriuretic peptide (BNP) for assessment of cardiac risk before non-cardiac surgery.

Methods: Consecutively treated patients (947 men, 643 women) whose BNP was measured before non-cardiac surgery were studied. Clinical and ECG variables were evaluated to identify predictors of postoperative cardiac events.

Results: Events occurred in 6% of patients: 21 cardiac deaths, 20 non-fatal myocardial infarctions, 41 episodes of pulmonary oedema and 14 patients with ventricular tachycardia. All of these patients had raised plasma BNP concentrations (best cut-off point 189 pg/ml). The only independent predictor of postoperative events was BNP (odds ratio 34.52, 95% confidence interval (CI) 17.08 to 68.62, $p < 0.0001$). Clinical variables of Goldman's multifactorial index identified 18% of patients in class I, 40% in class II, 24% in class III and 18% in class IV preoperatively; postoperative event rates were 2%, 3%, 7% and 14%, respectively. BNP identified 60% of patients as having zero risk (BNP 0–100 pg/ml), 22% low risk (101–200 pg/ml), 14% intermediate risk (201–300 pg/ml) and 4% high risk (> 300 pg/ml); postoperative event rates were 0%, 5%, 12% and 81%, respectively.

Conclusions: In this population of patients evaluated before non-cardiac surgery, BNP is an independent predictor of postoperative cardiac events. BNP > 189 pg/ml identified patients at highest risk.

Perioperative cardiac complications such as cardiac death, myocardial infarction, unstable angina, pulmonary oedema and serious ventricular arrhythmias are potentially avoidable causes of morbidity and mortality in patients undergoing non-cardiac surgery.^{1,2} Identification of patients at moderate to high risk for perioperative events can lead to treatments that lower risk of surgery, or the surgeon and patient can get a better idea of the risk of surgery. The presence of poor left ventricular systolic or diastolic dysfunction may predictive perioperative cardiac events.^{3–9} Symptoms of heart disease may be absent or blunted in patients limited by orthopaedic, pulmonary or other superimposed disability. Clinical evaluation alone, therefore, may be insufficient to risk stratify patients with such limitations, and clearly there is room for improvement in diagnosis. Brain natriuretic peptide (BNP) offers a diagnostic breakthrough in the approach to heart disease.¹⁰ The purpose of this study was to determine the value of preoperative assessment of cardiac risk of using BNP before non-cardiac surgery in consecutive patients.

METHODS

Study population

Plasma BNP concentrations were measured in 1638 consecutive patients for risk stratification before expected non-cardiac surgery. They were all admitted for surgery including the day-case group, last-minute preoperative cardiology consultation and selected major operations. Twelve patients with raised BNP (> 189 pg/ml) had an intervening event—pulmonary oedema in 10 patients and myocardial infarction in two patients—before non-cardiac surgery and were excluded from further analysis. Furthermore, 36 patients (2%) without an intervening event had increased BNP concentrations (> 460 pg/ml) resulting in cancellation of surgery. All of them were in New York Heart Association (NYHA) functional class IV. The remaining 1590 patients

underwent non-cardiac surgery within three days after the BNP measurement and constituted the study group.

Clinical characteristics of the patients were recorded at the time of BNP measurement. The Goldman multifactorial cardiac risk index¹¹ was calculated for each patient according to the number of the following criteria that were present (table 1). On the basis of the number of positive criteria, patients were divided into class I (0 to 5), II (6 to 12), III (13 to 25) or IV (> 26) points. Left ventricular ejection fraction was measured preoperatively in 854 patients (55%). The biplane method of discs was used from the apical four-chamber view.¹²

Table 1 Goldman multifactorial cardiac risk index

Criteria	Score
1. History	
Age > 70 years	5
Myocardial infarction in previous 6 months	10
2. Physical examination	
Third heart sound gallop or jugular vein dilatation	11
Important valvular aortic stenosis	3
3. ECG	
Rhythm other than sinus or atrial extrasystoles on last preoperative ECG	7
> 5 ventricular extrasystoles/min documented at any time preoperatively	7
4. General status	
$PO_2 < 60$ or $PCO_2 > 50$ mm Hg, $K < 3.0$ or $HCO_3 < 20$ mmol/l, BUN > 50 or creatinine > 265 μ mol/l, abnormal SGOT, signs of chronic liver disease or patient bedridden for non-cardiac causes	3
5. Operation	
Intraperitoneal, intrathoracic or aortic operation	3
Emergency operation	4
Total	53

BUN, blood urea nitrogen; PCO_2 , partial pressure of carbon dioxide; PO_2 , partial pressure of oxygen; SGOT, serum glutamic-oxaloacetic transaminase.

Table 2 Characteristics of the study population

Characteristics	No events (n = 1494)	Events (n = 96)
Men	890 (60%)	57 (59%)
Cardiac history		
Previous MI	429 (29%)	48 (50%)*
Previous CABG or PCI	370 (25%)	80 (83%)*
Typical angina	284 (19%)	34 (35%)*
CHF	257 (17%)	29 (30%)*
NYHA I	170 (66%)	0
NYHA II	87 (34%)	18 (62%)*
NYHA III	0	11 (38%)
NYHA IV	0	0
Cardiac risk factors		
Tobacco use	904 (61%)	82 (85%)*
Hypertension	895 (60%)	75 (78%)*
Hypercholesterolaemia	728 (49%)	67 (70%)*
Diabetes mellitus	348 (23%)	50 (52%)*
Family history of CAD	821 (55%)	54 (56%)*
Age ≥ 70	672 (45%)	92 (96%)*
Goldman cardiac risk index		
Class I	280 (19%)	6 (6%)
Class II	614 (41%)	22 (23%)
Class III	354 (24%)	28 (29%)
Class IV	246 (17%)	40 (42%)
BNP (pg/ml)	101.3 (79.5)	314.7 (91.3)*
BNP ₁₈₉	236 (16%)	81 (84%)*

Data are mean (SD) or number (%).

*p<0.001.

BNP, brain natriuretic peptide; BNP₁₈₉, best cut-off point on the receiver operation characteristic curve; CABG, coronary artery bypass graft; CAD, coronary artery disease; CHF, congestive heart failure; MI, myocardial infarction; NYHA, New York Heart Association; PCI, percutaneous coronary intervention.

During the hospitalisation period (3–17 days, median 5.2 days) the records of the 1590 patients were reviewed for the presence of postoperative hard cardiac events. Cardiac events were determined by postoperative serial cardiac enzyme values, postoperative ECG and echocardiographic data, which were obtained in 954 patients (60%), including all patients who experienced angina, dyspnoea, heart failure, significant haemodynamic changes, ventricular arrhythmias or atrial arrhythmias requiring treatment. Cardiac death was defined as cardiac-cause death during the hospitalisation period. Myocardial infarction was defined as a perioperative cardiac enzyme rise by use of a prespecified concentration of greater than twice the upper limit of normal or development of a new Q wave on the postoperative ECG associated with a cardiac enzyme rise consistent with myocardial necrosis. Acute pulmonary oedema was diagnosed by either physical examination or chest radiography. Ventricular arrhythmia was assessed by ECG. The end point was assessed as a first event, without double counting of clinical events for the same patient.

BNP measurements

All patients underwent routine laboratory tests and BNP from a fresh plasma sample. BNP was measured with an AxSYM system (Axis-Shield Diagnostics, Dundee, UK). BNP

was measured quantitatively by means of a microparticle enzyme immunoassay. EDTA plasma was used for the AxSYM BNP assay. Samples were collected in plastic collection tubes. BNP binds to the coated microparticles with monoclonal antibody to form antigen–antibody complexes. The specific process yields the fluorescent product 4-methylumbelliferone, which is measured by the optical assembly. The AxSYM BNP assay's imprecision was $\leq 12\%$ in a study run according to the National Committee for Clinical Laboratory Standards protocol EP5-A.¹³ The analytic sensitivity of the assay was ≤ 15 pg/ml in a study where the AxSYM BNP Standard Calibrator A (0 pg/ml) was assayed multiple times. Concordance with a commercially available diagnostic kit was 91.4%.¹⁴

Statistical analysis

Continuous variables were summarised as mean (SD), and group comparisons were based on the Wilcoxon rank sum test. Categorical variables were summarised as a percentage of the group total, and comparisons between groups were based on the χ^2 test. Associations between cardiac events and clinical variables were examined with logistic regression. Most cardiac events occurred 48 h and 72 h after the operation (73% and 91%, respectively); thus, Cox regression analysis could not be used. Independent variables used for analysis were previous myocardial infarction, coronary artery bypass surgery or percutaneous coronary intervention, history of congestive heart failure, important valvular aortic stenosis, typical angina, a rhythm other than sinus on the last preoperative ECG, ST segment and T wave changes or left bundle branch block on the baseline ECG, echocardiographic left ventricular hypertrophy (left ventricular mass index), left ventricular ejection fraction (both entered as continuous variables) and A:E ratio from transmitral Doppler blood flow velocity > 1 , drugs (β blockers, angiotensin-converting enzyme inhibitor, diuretics, etc), serum creatinine > 265 μ mol/l, type of surgery, Goldman index, signs of

Table 4 Univariate clinical and BNP predictors of postoperative events in 1590 patients undergoing non-cardiac surgery

Variable	OR	95% CI	p Value
Goldman index			
I	Reference group		
II	2.36	0.94 to 5.96	0.05
III	2.63	1.10 to 6.32	0.03
IV	5.06	2.09 to 12.28	0.0003
Previous MI	2.48	1.64 to 3.76	0.00001
History of CHF	2.08	1.32 to 3.29	0.0016
Typical angina	2.34	1.51 to 3.62	0.0001
LVEF	7.96	3.89 to 14.02	0.001
BNP	1.025	1.021 to 1.029	0.00001
BNP ₁₈₉	28.78	16.31 to 50.81	0.00001

BNP, brain natriuretic peptide; BNP₁₈₉, best cut-off point on the receiver operation characteristic curve; CI, confidence interval; CHF, congestive heart failure; LVEF, left ventricular ejection fraction; MI, myocardial infarction; OR, odds ratio.**Table 3** Cardiac events according to BNP in four groups

BNP (pg/ml)	Number	Cardiac deaths (n = 21)	Non-fatal MI (n = 20)	APO (n = 41)	VT (n = 14)	Total (n = 96)
<100	954	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
100–200	349	1 (1%)	3 (3%)	10 (20%)	2 (9%)	16 (5%)
200–300	223	4 (2%)	7 (5%)	12 (45%)	5 (53%)	283 (13%)
>300	64	16 (50%)	10 (71%)	19 (80%)	7 (96%)	52 (81%)

APO, acute pulmonary oedema; BNP, brain natriuretic peptide; MI, myocardial infarction; VT, ventricular tachycardia.

chronic liver disease, family history of coronary artery disease, tobacco use, hypertension, hypercholesterolaemia, diabetes mellitus, sex, and age. BNP variables were entered into the model in a stepwise forward selection manner. Three BNP variables were used: BNP as a continuous variable, BNP divided in four categories with respect to the risk of cardiac event (zero risk, 0; low risk, 1; intermediate risk, 2; and high risk, 3) and BNP₁₈₉ divided in two groups with low BNP < 189 pg/ml (0) and with high BNP ≥ 189 pg/ml (where BNP 189 pg/ml was the best cut-off point on the receiver operation characteristic curve). Entry and retention were set at a significance level of 0.05. Data were analysed with SPSS REGRESSION (SPSS V.8.0 for Windows; SPSS Inc, Chicago, Illinois, USA) with the collinearity diagnostics option and assistance from SPSS EXPLORE for evaluation of regression assumptions. All statistical assumptions were met and we found no multicollinearity problems in our analysis. Odds ratio and its 95% confidence interval were calculated.

All patients without a hard cardiac event also had low BNP, from 0 to 100 pg/ml. Therefore, patients with BNP 0–100 pg/ml were considered to be the zero-risk group. On the other hand, many patients with BNP > 300 pg/ml (81%) had hard cardiac events and were considered to be the high-risk group. The rest of the patients with intermediate BNP plasma concentrations of 101–200 pg/ml and 201–300 pg/ml had intermediate event rates of 5% and 12%, respectively, and were regarded as low and intermediate-risk groups.

Sensitivity and specificity to predict hard cardiac events were calculated at various cut-off points from 0 to 460 pg/ml BNP. To assess the optimal BNP cut-off point that most correctly predicts cardiac events, the squared standardised log odds ratio statistic was applied. The optimal cut-off point corresponds to the maximum squared log odds ratio.

RESULTS

Patient characteristics

The mean age of the patients was 70 (7) years (range 35–91 years). Table 2 describes the clinical characteristics of the study population. Eighty patients (5%) had renal insufficiency with creatinine concentrations ≥ 265 µmol/l; the mean concentration of creatinine in the whole population was 106 (71) µmol/l. Five hundred and thirty patients (33%) were taking β blockers, 600 (38%) angiotensin-converting enzyme inhibitor or angiotensin II receptor antagonist, and 450 (28%) diuretics. The baseline ECG was normal in 477 patients (30%) and showed previous myocardial infarction in 318 patients (20%), left ventricular hypertrophy in 95 patients (6%) and left bundle branch block in 111 patients (7%).

Results of BNP

The most common recommendations to counter increased BNP concentrations (> 100 pg/ml) were to adjust or change the drugs taken by 163 patients (10%) and to have the cardiology consultant service follow up 61 (4%) patients postoperatively. There were 193 patients (68%) in Goldman

Table 6 Predictive values of BNP and Goldman's risk index

	BNP	Goldman index
Number of patients	1590	1590
Event present/absent	96/1494	96/1494
Sensitivity	100%	100%
Specificity	75%	0%
Positive predictive value	26%	6%
Negative predictive value	99%	Infinity
ROC area	0.84	0.61
95% CI	0.83 to 0.87	0.54 to 0.68
Cut-off point	189	Class IV

BNP, brain natriuretic peptide; ROC, receiver operating characteristic curve.

Figure 1 Predictive value of brain natriuretic peptide (BNP) in relation to presence or absence of events. Progressive increase in risk of events is stratified by the Goldman index. In each Goldman class BNP > 189 pg/ml identified a significantly increased risk than BNP ≤ 189 pg/ml. Numeric values indicate percentage of event rates.

class I and 305 patients (48%) in Goldman class II who had plasma BNP concentrations > 100 pg/ml.

Postoperative events

Non-cardiac surgery in the 1590 patients were orthopaedic procedures in 636 patients (40%), abdominal in 477 (30%), obstetric and gynaecological in 318 (20%), and head and neck in 159 (10%). Postoperative cardiac events occurred in 96 patients (6%): 21 cardiac deaths, 20 non-fatal myocardial infarctions, 41 episodes of pulmonary oedema and 14 patients with ventricular tachycardia (table 3). Fifteen patients (16%) entered the intensive care unit for tracheal incubation; inotropes were given to 70 patients (73%), levosimendan to 20 patients (21%), and additional doses of diuretics to 90 patients (94%). There were no non-cardiac deaths and 31 (2%) cases of suspected pulmonary infarctions, seven of them presenting as an infiltrate on chest radiography.

Univariate and multivariate analyses

Table 4 presents univariate predictors of postoperative cardiac events. The clinical variables (model 1; table 5) that were significantly associated with a cardiac event in the study cohort were echocardiographic left ventricular ejection fraction and previous myocardial infarction. The only BNP variable that added incrementally to the clinical model was BNP₁₈₉. After BNP₁₈₉ was added to the model, history of myocardial infarction and left ventricular ejection fraction

Table 5 Multivariate predictors of postoperative events

Variable	OR	95% CI	p Value
Model 1			
LVEF	7.45	3.09 to 13.55	0.001
Previous MI	2.75	1.54 to 3.92	0.001
Final model			
BNP ₁₈₉	34.52	17.08 to 68.62	0.00001

CI, confidence interval; LVEF, left ventricular ejection fraction; MI, myocardial infarction; OR, odds ratio.

Table 7 Predictive value of BNP in relation to Goldman's classes

Goldman class	Crude event rates		OR	95% CI
	BNP >189	BNP ≤189		
I	7.9%	0.5%*	3.8	1.9 to 5.1
II	12%	1%*	3.4	2.5 to 4.3
III	60%	2%*	8.2	5.5 to 11.8
IV	78%	1.7%*	5.6	4.2 to 7.4

*p<0.001.

BNP, brain natriuretic peptide; CI, confidence interval; OR, odds ratio.

Table 8 Risk stratification of the population according to Goldman index and BNP (in quartiles) with corresponding event rates (in parentheses) and p value for difference

BNP (pg/ml)	Number	Goldman class				Total
		I (n = 286)	II (n = 636)	III (n = 382)	IV (n = 286)	
<100	954	Reference group (0%)				
100–200	349	2.1* (1%)	3.0* (3%)	9.9* (20%)	5.1 (9%)	3.7* (5%)
200–300	223	3.2* (2%)	3.6* (5%)	16.6* (45%)	11.2 (53%)	5.3* (12%)
>300	64	15.8* (50%)	24.6* (71%)	21.8* (80%)	8.2 (96%)	15.9* (81%)
Total		1.4* (2%)	1.5* (3%)	1.8* (7%)	1.7* (14%)	1.6* (6%)

*p<0.001.

BNP, brain natriuretic peptide.

were no longer significant. The final model included only BNP₁₈₉ (table 5).

BNP₁₈₉

Table 6 presents the predictive values and the c statistics of BNP and Goldman's risk index.

Goldman's index versus BNP

Goldman's index identified 286 patients (18%) in class I, 636 (40%) in class II, 382 (24%) in class III and 286 (18%) in class IV risk for postoperative cardiac events. These patients had event rates of 2%, 3%, 7% and 14%, respectively. The BNP categories based on the plasma concentrations of BNP and the risk of postoperative events identified 954 (60%) at zero risk, 349 (22%) at low risk, 223 (14%) at intermediate risk, and 64 (4%) at high risk for postoperative hard cardiac events. These patients had event rates of 0%, 5%, 12% and 81%, respectively.

In all Goldman classes, BNP identified a group of patients with increased risk of postoperative events (fig 1, table 7). Table 8 presents the relative risk with corresponding event rates in categories divided by Goldman class and by BNP (in quartiles). Figure 2 illustrates the BNP of patients with and without an event.

Two hundred and twenty-four patients (78%) identified in class IV by Goldman criteria would have been placed in the low risk group by BNP < 189 pg/ml and 339 patients (89%) identified in class III by Goldman criteria would have been placed in the low risk category by BNP < 189 pg/ml. Seventy-eight patients (81%) might have been saved and avoided a cardiac event by using BNP > 189 pg/ml rather than the Goldman criteria (if the optimum cut-off point selected were class IV) and 61 patients (64%) might have been saved and avoided a cardiac event by using BNP > 189 pg/ml rather than the Goldman criteria (if the optimum cut-off point selected were class III).

DISCUSSION

As a predictor of postoperative events, BNP appeared superior to Goldman's multifactorial clinical index. Raised BNP was an independent predictor of postoperative cardiac events before non-cardiac surgery.

Similar results have been reported by Yeh *et al.*¹⁵ who found that preoperative plasma N-terminal pro-BNP concentration independently predicted cardiac complications in patients undergoing non-cardiac surgery. In 190 consecutive patients who underwent elective non-cardiac surgery an N-terminal pro-BNP concentration > 450 ng/l predicted cardiac complications with a sensitivity of 100% and a specificity of 82.9%.

Study limitations

The lack of blinding substantially confounded the results because clinicians used the results of BNP to manage patients; thus, treatment bias was unavoidable. The BNP concentrations as a known predictor of heart failure when found raised led the clinicians to recommendations such as to cancel the operation or to change drug treatment and to follow up the patient postoperatively. The inclusion of these patients could have led to an even lower positive predictive value of BNP; this is an important limitation of the study. Treatment of an additional 163 patients (10%) included in

Figure 2 Brain natriuretic peptide (BNP) in patients with and without an event in each Goldman group. Patients with low risk by the Goldman index who actually had an event can be identified by increased BNP and, conversely, patients with high risk by the Goldman index with no event can be identified by decreased BNP. Numeric values indicate number of patients.

the study was changed. Most were in an intermediate- to high-risk group. Nevertheless, patients at low clinical risk also had cardiac events, and BNP was useful for identifying these patients. However, only a few studies have blinded clinicians to the results of methods of risk stratification for non-cardiac surgery. In most studies results affected management, and the positive predictive value ranged from 7–23%.¹⁶

Another important limitation was that we had postoperative laboratory data, including cardiac enzymes, ECGs and echocardiograms, for only 60% (954) of patients. These tests were obtained according to the symptoms and the findings of a physical examination and the whole population was followed up for clinical events. Lastly, myocardial perfusion scans were not studied and may reduce the superiority of BNP; this is particularly important given that > 30% of patients had a cardiac history.¹⁷ However, BNP is a potentially simpler bedside test with fewer resource implications.

The microparticle enzyme immunoassay on AxSYM has better sensitivity than the point-of-care Triage BNP assay for patients in NYHA class I with chronic heart failure, whereas the sensitivity of the two assays is similar for patients presenting with more symptoms (NYHA II–IV). For screening purposes, therefore, cut-off plasma BNP concentrations should be specific for each assay to optimise test performance.^{18–20}

BNP for prediction of perioperative cardiac events

We found a relatively high event rate, which is comparable with the pooled average for large studies involving patients referred for preoperative testing^{21–22} and supports the suggestion that further risk stratification is needed in this population. BNP release is related to the degree of myocardial involvement and appears to provide important prognostic information. The predictive value of BNP was not restricted to the single end point of death but also predicted non-fatal myocardial infarction, acute pulmonary oedema and ventricular tachycardia. The data from the present study further support the hypothesis that ischaemia is an important trigger for BNP release. Furthermore, ventricular tachycardia can induce BNP synthesis through an increase in wall stress, or tachycardia can directly induce BNP release from cardiomyocytes. It has been reported that BNP is highly specific for the detection of myocardial involvement but is released regardless of the cause of the haemodynamic perturbation.²³ A recent study of patients with stable coronary heart disease showed that raised BNP concentration is independently associated with inducible ischaemia.²⁴ The concentration of BNP may reflect the size or severity of the myocardial ischaemia, even when myocardial necrosis has not yet occurred. BNP synthesis is detectable in both the infarcted and non-infarcted myocardium.²⁵

Another interesting finding of this study was that many patients with increased plasma concentrations were in Goldman class I or II. Plasma BNP testing may be warranted for these subgroups of clinically low- or moderate-risk patients. Although these patients may be classified as low risk by clinical criteria, BNP may improve delineation of risk.

Utility of BNP best cut-off point (≥ 189 pg/ml)

Factors other than preoperative BNP concentrations can influence the occurrence of serious cardiac events. These factors may be surgical complications or incidences related to surgical procedures that may occur after baseline measurement and can influence cardiac function. BNP < 189 pg/ml but > 100 pg/ml is not in the normal range of BNP values. Thus, cardiac events, although rare among patients with low BNP < 189 pg/ml, could not be excluded. In fact we found 15 patients with serious cardiac event who had decreased BNP

(< 189 pg/ml) and 233 patients without any postoperative cardiac event who had raised BNP (> 189 pg/ml). Moreover, left ventricular dysfunction and heart failure may well be present even at BNP concentrations < 100 pg/ml and particularly before myocardial infarction in the absence of left ventricular dysfunction. Therefore, BNP < 100 pg/ml cannot exclude imminent myocardial infarction or asymptomatic left ventricular dysfunction. However, in our study no patients with low BNP < 100 pg/ml had cardiac events because BNP represents the current haemodynamic loading of the heart and the current functional capacity. Thus, patients with well-compensated left ventricular dysfunction at the time of surgery as expressed by low BNP may well tolerate the non-cardiac procedure without cardiac complications.

Conclusions

In this population of 1590 patients undergoing non-cardiac surgery, BNP was the only independent predictor identifying patients at risk of cardiac events. BNP > 189 pg/ml identified patients at high risk, despite low or intermediate-risk categorisation by clinical variables, whereas a normal study predicted an excellent outcome (negative predictive value 100%) regardless of risk stratification by clinical variables. BNP may be the only easily used biochemical test that can provide the clinician with a non-invasive tool to identify preoperative patients who are at major risk. Whether serial measurements of BNP may be used to identify more rapidly those patients suitable for early discharge or more intensive treatment deserves future prospective studies.

Authors' affiliations

J Dernellis, M Panaretou, Department of Cardiology, Vostanion Hospital, Mytilini, Greece

REFERENCES

- 1 Goldman L. Cardiac risks and complications of noncardiac surgery. *Ann Intern Med* 1983;**98**:504–13.
- 2 Mangano DT. Perioperative cardiac morbidity. *Anesthesiology* 1990;**72**:153–84.
- 3 Kazmers A, Cerqueira MD, Zierler RE. The role of preoperative radionuclide ejection fraction in direct abdominal aortic aneurysm repair. *J Vasc Surg* 1988;**8**:128–36.
- 4 Gerson MC, Hurst JM, Hertzberg VS, et al. Cardiac prognosis in noncardiac geriatric surgery. *Ann Intern Med* 1985;**103**:832–7.
- 5 Halm EA, Browner WS, Tubau JF, et al. Echocardiography for assessing cardiac risk in patients having noncardiac surgery. Study of Perioperative Ischemia Research group. *Ann Intern Med* 1996;**125**:433–41.
- 6 Freeman WK, Gibbons RJ, Shub C. Preoperative assessment of cardiac patients undergoing noncardiac surgical procedures. *Mayo Clin Proc* 1989;**64**:1105–17.
- 7 Gage AA, Bhayana JN, Balu V, et al. Assessment of cardiac risk in surgical patients. *Arch Surg* 1977;**112**:1488–92.
- 8 Stevenson LW. The limited availability of physical signs for estimating hemodynamics in chronic heart failure. *JAMA* 1989;**261**:884–8.
- 9 Gottdiener JS, McClelland RL, Marshall R, et al. Outcome of congestive heart failure in elderly persons: influence of left ventricular systolic function. The cardiovascular health study. *Ann Intern Med* 2002;**137**:631–9.
- 10 McCullough PA. B-type natriuretic peptides: a diagnostic breakthrough in heart failure. *Minerva Cardioangiol* 2003;**51**:121–9.
- 11 Goldman L, Caldera DL, Nussbaum SR, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med* 1977;**297**:845–50.
- 12 Dernellis JM, Panaretou MP. Effects of digoxin on left atrial function in heart failure. *Heart* 2003;**89**:1308–15.
- 13 National Committee for Clinical Laboratory Standards. *Evaluation of precision performance of clinical chemistry devices: approved guideline*, NCCLS Document EP5-A. Wayne, Pennsylvania: NCCLS, 1999.
- 14 National Committee for Clinical Laboratory Standards. *Method comparison and bias estimation using patient samples: approved guideline*, NCCLS Document EP9-A. Wayne, PA: NCCLS, 1995.
- 15 Yeh HM, Lau HP, Lin JM, et al. Preoperative plasma N-terminal pro-brain natriuretic peptide as a marker of cardiac risk in patients undergoing elective non-cardiac surgery. *Br J Surg* 2005;**92**:1041–5.
- 16 Cohen MC, Eagle KA. The role of the cardiology consultant. In: Topol EJ, eds. *Comprehensive cardiovascular medicine*. Philadelphia: Lippincott-Raven, 1147–71).

- 17 **Brown KA**, Rowen M. Extent of jeopardized viable myocardium determined by myocardial perfusion imaging best predicts perioperative cardiac events in patients undergoing noncardiac surgery. *J Am Coll Cardiol* 1993;**21**:325–30.
- 18 **Tang WHW**, Philip K, Hazen SL, *et al*. Comparative sensitivities between different plasma B-type natriuretic peptide assays in patients with minimally symptomatic heart failure. *Clin Cornerstone* 2005;**7**(suppl 1):S18–24.
- 19 **Tang WH**, Girod JP, Lee MJ, *et al*. Plasma B-type natriuretic peptide levels in ambulatory patients with established chronic symptomatic systolic heart failure. *Circulation* 2003;**108**:2964–6.
- 20 **Mueller T**, Gegenhuber A, Poetz W, *et al*. Preliminary evaluation of the AxSYM B-type natriuretic peptide (BNP) assay and comparison with the ADVIA Centaur BNP assay. *Clin Chem* 2004;**50**:1104–6.
- 21 **Eagle KA**, Berger PB, Calkins H, *et al*. ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1996 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). *J Am Coll Cardiol* 2002;**39**:542–53.
- 22 **Mangano DT**, Goldman L. Preoperative assessment of patients with known or suspected coronary disease. *N Engl J Med* 1995;**333**:1750–6.
- 23 **Heeschen C**, Hamm CW, Mitrovic V, *et al*. N-terminal Pro-B-type natriuretic peptide levels for dynamic risk stratification of patients with acute coronary syndromes. *Circulation* 2004;**110**:3206–12.
- 24 **Bibbins-Domingo K**, Ansari M, Schiller NB, *et al*. B-type natriuretic peptide and ischemia in patients with stable coronary disease: data from the Heart and Soul Study. *Circulation* 2003;**108**:2987–92.
- 25 **Hama N**, Itoh H, Shirakami G, *et al*. Rapid ventricular induction of brain natriuretic peptide gene expression in experimental acute myocardial infarction. *Circulation* 1995;**92**:1558–64.

IMAGES IN CARDIOLOGY

doi: 10.1136/hrt.2005.085001

Focal femoral artery narrowing caused by suture mediated closure device

This case illustrates a puncture-site arterial narrowing due to complications resulting from the use of a suture-mediated closure device. We treated it successfully by balloon angioplasty. However, we could not explain how the complication occurred. Could we explain this finding as a thrombotic occlusion or an inflammatory reaction?

For evaluation of renal artery stenosis, a 75-year-old woman underwent a peripheral angiogram from a right femoral artery puncture, using a 6 French vascular sheath. The angiogram revealed minimal luminal narrowing in both renal arteries and no significant luminal narrowing at the right femoral artery puncture site (panel A). After the procedure, the arteriotomy site was closed with a 6 French Perclose AT device (Perclose; Redwood City, California, USA) without immediate complications. There was no evidence of a haematoma or bruit at the puncture site the next day and the patient was discharged the day after the arteriogram. One month later, she complained of severe right calf pain and intermittent claudication of the right leg. During the past month, there were no signs of infection and inflammation in the puncture site. Physical examination revealed a decrease in the pulsation of the right dorsalis pedis artery. Therefore, peripheral angiography was again undertaken via the left femoral artery access. The selective right femoral artery angiogram revealed focal severe luminal narrowing at the right superficial femoral artery (panel B). The narrowing was different from the atherosclerotic stenosis in morphology. The

(A) Right femoral arteriogram taken before closure of the puncture site shows a 6 French vascular sheath in the femoral artery. There was no significant stenosis at the femoral artery. (B) One month after the procedure a right femoral arteriogram was performed from a left femoral approach, showing a severe focal stenosis (arrow) at the origin of the superficial femoral artery. (C) Post-angioplasty arteriogram shows satisfactory dilatation of the narrowing with good flow in the superficial femoral artery.

balloon angioplasty was done at the narrowing lesion. The final arteriogram revealed no residual stenosis and excellent blood flow in the superficial femoral artery (panel C). The patient was discharged the next day and the claudication and right calf pain resolved. The patient has remained asymptomatic for three months after angioplasty.

J-Y Moon
S Park
D Choi

cdhlyj@yumc.yonsei.ac.kr