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Original Article

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Role of Ankle-Brachial Index Measured with Simple Automated Blood Pressure Devices in Predicting the Postoperative Kidney Functions in Non-Cardiac Patients with Low Renal Risk

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ABSTRACT

Objective: Ankle-brachial index indirectly shows subclinical atherosclerosis in extremity vessels. No study investigated the role of ankle-brachial index measured with simple automated devices in the prediction of postoperative acute kidney injury in non-cardiac surgery patients with a low risk of acute kidney injury.
Methods: The single-center, cross-sectional, observational study included patients who were scheduled for operation under general anesthesia. The preoperative ankle-brachial index was measured with two Omron M2 Basic (Hem 7120-E) automatic sphingomanometry devices for the detection of the arm and leg systolic blood pressure values. The ratio of ankle higher systolic blood pressure to brachial higher systolic blood pressure was recorded as ankle-brachial index.
Results: A total of 100 (48 women, mean age of 57.5 ± 14.1 years) patients were included. The median ankle-brachial index value was 1.12 (right ABI: 1.11 ± 0.09 and left ABI: 1.12 ± 0.10). The level of ankle-brachial index in patients with acute kidney injury was not significantly different than in patients without acute kidney injury. Serum creatinine value was increased on the second day compared to baseline in 38 (38%) of patients. There was no difference in terms of ankle-brachial index levels in patients with and without an increase in creatinine levels. In the linear regression model including the parameters that were found to be related to the change in the second-day serum creatinine in univariate analyses, left ankle-brachial index showed a negatively significant relationship with the second-day serum creatinine change.
Conclusion: Ankle-brachial index is useful in the assessment of perioperative renal function and acute kidney injury risk in non-cardiac surgery patient populations.
Keywords: Acute kidney injury, ankle-brachial index, perioperative care

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INTRODUCTION

Acute kidney injury (AKI) is an important perioperative complication that increases patient mortality and morbidity. Although several risk factors for the development of postoperative AKI have been identified, particularly the presence of preoperative renal dysfunction, it may develop for many reasons, even in patients without known preoperative AKI risk factors.[1,2] And AKI had more cardiovascular complications (33.3% vs. 11.3%, $P < .001$) and a higher in-hospital mortality rate (6.1% vs. 0.9%, $P = .003$) compared with patients without AKI. Moreover, there are some models suggested for the prediction of AKI or identifying undiagnosed AKI in hospitalized patients, which may lead to better disease management.[3] In a recent study, Lei et al[4] examined whether adding preoperative and intraoperative data is associated with improved prediction of noncardiac postoperative AKI in a study conducted at 4 tertiary academic hospitals' electronic health record data in the United States.[4] Among 42 615 patients, the rate of postoperative AKI was 10.1% (n = 4318). In a recent systematic review, Wilson et al[5] identified 7 models from 6 articles, which have not been validated yet, and the final model included 4 and 11 independent variables risk prediction models for AKI following non-cardiac surgery.[5]

None of these studies investigated the influence of ankle-brachial index (ABI) in the estimation of postoperative AKI in non-cardiac surgery patients with low risk for AKI.

ABI is the ratio of ankle higher systolic blood pressure (BP) to brachial higher systolic BP. This method, which can be applied quickly and easily, has been used for the diagnosis and severity of lower extremity peripheral artery disease for many years. In patients with significant peripheral arterial stenosis, significant levels of sensitivity and specificity have been demonstrated.[6] ABI, which directly shows atherosclerotic disease in the lower extremity, indirectly shows atherosclerosis in other vascular systems, and ABI levels are also associated with mortality and morbidity of coronary artery disease and cerebrovascular disease (CVD).[7-10]

The measurement with the Doppler devices is the gold standard application of ABI. Although age, gender, height, ethnicity can affect the ABI, it is generally accepted that being lower than 0.9 suggests a decrease in distal blood flow.[11] This is considered a risk factor for CVD both in the uremic and non-uremic populations.[12,13] However, especially in the ABI study with automatic BP measuring instruments, the results were shown to be similar. For example, Davies et al[14] showed that automated BP device measurements had comparable results with the Doppler devices in their study including 308 with risk factors for CVD; the mean difference between the two methods was 0.016 ± 0.1, 95% limits of agreement: ± 0.2 In this study, the sensitivity and specificity of an automated device for the detection of PAD were 98% and 75%, respectively.

Investigation of the relationship between preoperative measured ABI and postoperative renal functional changes may yield significant results, and using automated BP devices instead of Doppler ultrasound may provide a broad clinical practice area. Therefore, we have conducted a pilot study investigating the relationship between preoperative ABI measured with automated BP devices and postoperative renal function change in a cohort without non-cardiovascular surgery with no significant risk factors for AKI development.

METHODS

The single-center, cross-sectional, observational study included consecutive patients over 18 years of age who were scheduled for operation under general anesthesia in the general surgery clinic of our hospital. The study was conducted between December 1, 2014 and June 1, 2015. Ethics committee approval was obtained for this study from the Haseki Training and Research Hospital (Approval Date: December 17, 2014; Approval Number: 170), and patients who gave consent were included. Patients with a history of acute or chronic renal failure, any limb amputation, history of renovascular intervention, presence of uncontrolled hypertension, advanced heart or liver failure, large vessel problems (aorta, vena cava inferior, etc.), the patients discharged earlier than 2 days postoperatively and, emergency operated patients were excluded from the study. Major complications (large vessel incision, shock, massive organ injury, etc.) that could cause AKI alone were excluded from the study.

The day before the operation, the patients were evaluated in their hospital beds. Demographic data, weight and height of the patients, information about the planned surgery, chronic diseases, medications, family history of chronic diseases, previous operations, and smoking status were questioned and recorded.

Evaluation of Renal Functions

Preoperative baseline and postoperative first and second-day serum urea, creatinine, electrolyte, albumin values were recorded. Operation-related surgery notes and study-related data observed during hospitalization were followed (the duration of the operation and whether any complications occurred during the surgery etc.). AKI was defined as an increase in serum creatinine by $\geq$0.3 mg/dL or an increase in serum creatinine to $\geq$1.5 times baseline within 48 hours, similar to The Acute Kidney Injury Network (AKIN) criteria.[15] However, since the hourly urine output of the patients was not monitored, it could not be used in the diagnosis of AKI.

ABI Measurement Method

In our study, we used two Omron M2 Basic (Hem 7120-E) automatic sphingomanometry devices for the detection of the arm and leg systolic BP values. In order to determine whether the BP devices gave equivalent results in systolic BP measurements, the arm and leg pressure readings on 10 healthy subjects were tested with both instruments. There was no difference between the readings of more than 5 mm Hg.

The patients included in our study were visited in their rooms of the ward the day before the operation. In the last 30 minutes, they did not smoke, drink tea or coffee, and rested in a supine position for 10 minutes in a quiet environment. Right brachial and right ankle systolic BPs, left brachial, and left ankle systolic BPs were measured at the same time. This procedure was repeated until there was no difference higher than 5 mm Hg with previous same site measurements. And the mean systolic BP values were calculated from the last two readings. The ratio of ankle higher systolic BP to brachial higher systolic BP was recorded as ABI.

Statistical Analysis

In statistical analysis, SPSS software 22.0 (IBM Corp., Armonk, NY, USA) for Windows program was used. In descriptive statistics,

MAIN POINTS

- Ankle-brachial index (ABI) indirectly shows subclinical atherosclerosis in extremity vessels.
- Simple automatic blood pressure measurement devices are easy, inexpensive, and practically applicable to ABI measurement instead of complicated and expensive Doppler devices.
- ABI may be an important indicator in demonstrating postoperative kidney function change.

number and percentage values were given for categorical variables, and mean, standard deviation, minimum and maximum values were given for numerical variables. Group-dependent comparisons of more than 2 groups were performed using Repeated Measure Analysis of Variance. Two dependent groups were analyzed by the Student's *t*-test or, if abnormally distributed, the Wilcoxon test. The relationship between numerical variables was studied with Spearman correlation analysis if the parametric test condition was not achieved.

In the linear regression model to find independent variables of second-day creatinine change, parameters that were significantly different in the univariate analysis were included. The statistical significance level was accepted as $P < .05$.

RESULTS

The study included a total of 100 (48 women and 52 men) patients with a mean age of 57.5 ± 14.1 years. The mean body mass index of the patients was 27.4 ± 5.0. The number of smokers was 47 (47%), and the median duration of smoking was 30 (IQR: 12-45) years. In the last 3 months, the rate of patients using angiotensin-converting enzyme inhibitor (ACEI) or angiotensinogen-2 blocker (ARB) was 18%. In history, 26% had hypertension, 17% had type 2 diabetes mellitus (DM), 8% had ischemic heart disease, and 1% had CVD. Operation types were as follows: bowel operation: 45, gastric surgery: 24, liver-bile operation: 15, breast operation: 6, thyroidectomy: 4, explorative laparotomy: 4, and splenectomy: 2. Also, 35% of the patients had a history of previous intrathoracic or intraabdominal surgery. The mean duration of surgical operation was 148.9 ± 73.5 (minimum: 50, maximum: 360) minutes. Preoperative mean systolic BPs were 142 ± 19 mm Hg, and mean diastolic BPs were 80 ± 11 mm Hg. There was a statistically significant difference in all laboratory parameters except urea on the first and second days of the study (Table 1).

Table 1. Preoperative and Postoperative Laboratory Parameters of the Patients

	Mean ± SD	Min	Max	*P*
Hemoglobin (g/dL)				
Preoperative	12.05 ± 2.42	6	19.7	<.001
Postoperative day 1	11.06 ± 1.70	8	16	
Postoperative day 2	10.51 ± 1.64	7	16.3	
Urea (mg/dL)				
Preoperative	31.77 ± 10.94	14	97	.451
Postoperative day 1	31.39 ± 12.12	6	66	
Postoperative day 2	33.08 ± 14.42	10.2	86	
Creatinine (mg/dL)				
Preoperative	0.76 ± 0.17	0.2	1.1	.016
Postoperative day 1	0.76 ± 0.22	0.2	1.6	
Postoperative day 2	0.77 ± 0.35	0.2	2.5	
Albumin (g/dL)				
Preoperative	3.90 ± 0.64	2.0	4.8	<.001
Postoperative day 1	3.17 ± 0.62	1.5	4.8	
Postoperative day 2	3.02 ± 0.49	1.7	4.2	
Calcium (mg/dL)				
Preoperative	9.22 ± 0.74	7.3	10.8	<.001
Postoperative day 1	8.29 ± 0.70	6.5	9.5	
Postoperative day 2	8.32 ± 0.66	6.6	10.2	
Sodium (mEq/L)				
Preoperative	138.82 ± 3.27	122	148	.001
Postoperative day 1	137.38 ± 2.63	129	144	
Postoperative day 2	137.71 ± 3.37	127	147	
Potassium (mEq/L)				
Preoperative	4.24 ± 0.50	3.0	5.2	<.001
Postoperative day 1	4.21 ± 0.47	3.2	5.7	
Postoperative day 2	4.02 ± 0.50	2.9	5.4	

ABI Results

The mean right ABI was 1.11 ± 0.09, and the left ABI was 1.12 ± 0.10. The mean left ABI was significantly higher than the right ABI (*P* = .015). None of the ABI levels were lower than 0.9. The median value was 1.12.

Renal Functions

In 38 (38%) patients, creatinine value was increased on the second day compared to baseline. Also, 18 (18%) patients showed an increase in serum creatinine value of more than 25% within 2 days postoperatively. There was no difference in terms of ABI levels in patients with and without an increase in creatinine levels (right ABI: 1.11 ± 0.09 in patients without creatinine increase, 1.10 ± 0.09 in patients with creatinine increase, *P* = .83; left ABI: 1.12 ± 0.10 in patients without creatinine increase, 1.11 ± 0.12 in patients with creatinine increase, *P* = .68). When patients were grouped according to the median value of the ABI level, there was no significant difference between these groups according to serum creatinine changes or the presence of a more than 25% increase in second-day serum creatinine.

AKI developed in 14 (14%) patients within 2 days postoperatively (Table 2). The level of ABI in patients with AKI was not significantly different than in patients without AKI (right ABI: 1.09 ± 0.09, left ABI: 1.10 ± 0.13 in patients with AKI; right ABI: 1.11 ± 0.08, left ABI: 1.12 ± 0.09 in patients without AKI, *P* = .33, *P* = .35, respectively).

Correlation Analyses

Right ABI positively correlated with preoperative creatinine and negatively correlated with albumin preoperative on the first

Table 2. The Characteristics of Patients According to the Development of AKI

	No-AKI (n = 86)		AKI (n = 14)		*P*
Age	56.2	14.2	65.0	10.9	.030
BMI	27.3	5.0	27.6	4.7	NS
Smoking (packs/years)	16.5	23.4	12.4	(28.5)	NS
Duration of surgery (minute)	144.2	69.5	191.7	101.8	NS
Urea (mg/dL) (preoperative)	31.7	11.1	32.4	10.0	NS
Urea (mg/dL) (postoperative day 2)	31.4	11.3	43.5	24.8	.003
Creatinine (mg/dL) (preoperative)	0.8	0.2	0.7	0.2	NS
Creatinine (mg/dL) (postoperative day 2)	0.7	0.2	1.2	0.7	<.001
Calcium (mg/dL) (preoperative)	9.3	0.7	9.0	0.9	NS
Sodium (mEq/L) (preoperative)	139.0	3.2	138.0	3.7	NS
Potassium (mEq/L) (preoperative)	4.2	0.5	4.4	0.4	NS
Hemoglobin (g/dL) (preoperative)	12.2	2.4	11.4	2.5	NS
Albumin (g/dL) (preoperative)	4.0	0.6	3.6	0.8	.04
Right ABI (preoperative)	1.09	0.09	1.10	0.13	NS
Left ABI (preoperative)	1.11	0.08	1.12	0.09	NS

ABI, ankle-brachial index; AKI, acute kidney injury; BMI, body mass index; NS, non-significant.

and second day and with calcium preoperative on the first and second day. Left ABI negatively correlated with postoperative albumin and calcium in first- and second-day levels (Table 3).

In female patients, left ABI negatively correlated with albumin on day 2 and calcium on day 1 postoperatively. In male patients, right ABI positively correlated with smoking and negatively correlated with preoperative first- and second-day albumin and preoperative first-day calcium.

Comorbidities, Drugs

When the mean ABI levels of 26 patients with hypertension were compared with those of 74 patients without hypertension, the right ABI level was significantly higher in hypertensives (Figure 1). Creatinine increase of more than 25% in the first 2 days postoperatively was significantly higher in the hypertensive group than the non-hypertensive group [8 patients (30.6%), 10 patients (13.5%), *P* = .049, respectively]. Similarly, AKI development was significantly higher in the hypertensive group than in the

Table 3. Relationship Between ABI and Clinical Features and Baseline Laboratory Parameters

	Right ABI		Left ABI	
	r	*P*	*r*	*P*
Age	0.036	.720	−0.025	.803
BMI	−0.095	.345	0.011	.915
Smoking (pack/year)	0.146	.148	0.087	.388
Hemoglobin (g/dL) (preoperative)	−0.156	.122	−0.037	.718
Hemoglobin (g/dL) (postoperative day 1)	−0.131	.212	−0.061	.558
Hemoglobin (g/dL) (postoperative day 2)	−0.129	.238	−0.076	.487
Urea (mg/dL) (preoperative)	0.172	.088	0.126	.213
Urea (mg/dL) (postoperative day 1)	0.098	.332	0.034	.738
Urea (mg/dL) (postoperative day 2)	0.153	.129	0.032	.751
Creatinine (mg/dL) (preoperative)	0.204	.041	0.043	.671
Creatinine (mg/dL) (postoperative day 1)	0.088	.386	−0.006	.949
Creatinine (mg/dL) (postoperative day 2)	0.079	.432	−0.034	.735
Systolic BP (mm Hg)	−0.035	.731	−0.026	.795
Diastolic BP (mm Hg)	−0.096	.340	−0.009	.926
Albumin (g/dL) (preoperative)	−0.259	.009	−0.121	.231
Albumin (g/dL) (postoperative day 1)	−0.464	<.001	−0.341	.001
Albumin (g/dL) (postoperative day 2)	−0.391	<.001	−0.337	.001
Calcium (mg/dL) (preoperative)	−0.253	.011	−0.098	.331
Calcium (mg/dL) (postoperative day 1)	−0.427	<.001	−0.309	.002
Calcium (mg/dL) (postoperative day 2)	−0.328	.001	−0.228	.025
Sodium (mEq/L) (preoperative)	−0.107	.290	−0.073	.472
Sodium (mEq/L) (postoperative day 1)	−0.068	.501	−0.006	.950
Sodium (mEq/L) (postoperative day 2)	0.082	.415	0.002	.983
Potassium (mEq/L) (preoperative)	−0.183	.069	−0.161	.109
Potassium (mEq/L) (postoperative day 1)	−0.010	.923	−0.059	.563
Potassium (mEq/L) (postoperative day 2)	−0.052	.611	−0.168	.094

ABI, ankle-brachial index; BMI, body mass index; BP, blood pressure.

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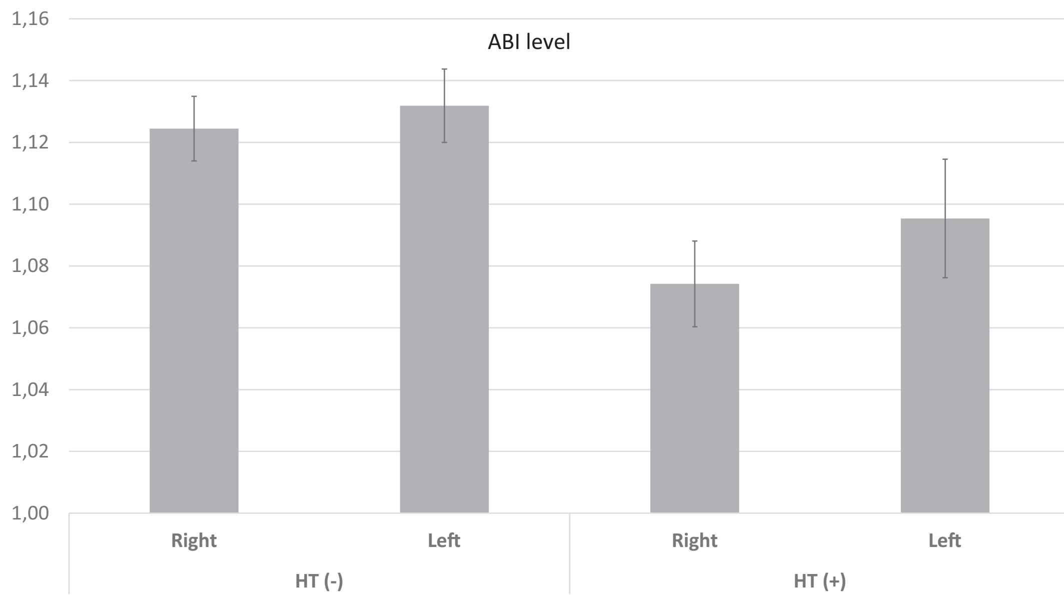

Figure 1. ABI level of the patient according to the presence or absence of hypertension.

non-hypertensive group in the first 2 days postoperatively [8 patients (30.6%), 6 patients (8.1%), respectively; *P* = .004].

In the patients not using ACEI and ARB at the last 3 months, right ABI positively correlated with preoperative first- and second-day urea and preoperative creatinine, whereas, it negatively correlated with preoperative and postoperative second-day hemoglobin, first- and second-day albumin, preoperative first- and second-day calcium. Left ABI negatively correlated with preoperative first- and second-day albumin and first- and second-day calcium.

In patients on ACEI or ARB, right ABI positively correlated with preoperative albumin and second-day hemoglobin, negatively correlated with first- and second-day urea, preoperative, first- and second-day creatinine. Left ABI negatively correlated with second-day urea, creatinine, and potassium and positively correlated with preoperative albumin.

In patients without DM, there was a statistically significant negative correlation between right ABI, preoperative albumin, calcium, and potassium on the first and second days. Left ABI negatively correlated with albumin levels on the first and second day and calcium on the first day.

In those with DM, right ABI correlated negatively with BMI, preoperative hemoglobin, albumin on postoperative first and second day, preoperative and postoperative first-day calcium levels. In this patient group, left ABI negatively correlated with preoperative hemoglobin, albumin on the first and second days.

Regression Analysis

In the linear regression model to find independent variables of second-day creatinine change, left ABI, presence of hypertension, RAS blocker use, and duration of operation were found to be independent variables, while age, gender, or presence of DM were not (Table 4).

DISCUSSION

AKI is an important condition that can cause high mortality and morbidity in hospitalized patients. The development of AKI, regardless of etiology, increases the length of hospital stay and all-cause mortality, especially in intensive care units and surgical clinics.[16-18] Many studies have been dedicated to predicting, identifying, and stratifying AKI that develop after non-cardiac surgery. Kheterpal S et al[19] investigated the incidence and risk factors for postoperative AKI after non-cardiac surgery patients with previously normal renal function in a prospective, observational, single-center study.[19] In this study, 121 of 15 102 patients

Table 4. Multivariate Analysis of Influential Parameters on the Change of Creatinine Level on Day 2 Compared to Baseline Creatinine

	B	Beta	*P*
Constant	50.737		
Age (years)	0.023	0.008	.945
Gender (F/M)	12.706	162	.173
Preoperative left ABI	−83.749	−0.229	.048
Duration of surgery (min)	0.196	0.366	.002
Presence of DM	2.674	0.030	.805
Presence of HT	55.567	0.627	.002
Use of RAS blockers	−41.877	−0.413	.028

ABI, ankle-brachial index; DM, diabetes mellitus; F/M, female/male; HT, hypertension; RAS, renin angiotensin system.

(0.8%) developed AKI, and age, emergent surgery, liver disease, body mass index, high-risk surgery, peripheral vascular occlusive disease, and chronic obstructive pulmonary disease necessitating chronic bronchodilator therapy were independent preoperative predictors. The same group also conducted a similar study in patients undergoing general surgery in 121 United States medical centers, in which 762 (1.0%) of 75 952 patients were complicated by AKI.[20] Biteker et al[21] showed that 6.7% of the patients had perioperative AKI in their study including a total of 1200 adult patients undergoing noncardiac, nonvascular surgery.[21] They showed age, diabetes, revised cardiac risk index, and the American Society of Anesthesiologists' physical status as independent predictors of AKI in multivariate analysis. Several risk factors that facilitate the development of AKI in the perioperative period have been shown in different studies.[22-24] The presence of preoperative renal dysfunction is the most crucial risk factor for the development of postoperative AKI.[1,2] In addition, advanced age, obesity, peripheral arterial disease, accompanying chronic lung, liver, and heart diseases, emergency surgery, and cardiovascular surgery interventions increase the risk of AKI.[1,2,25] Most of the studies on this subject have been performed in patients who underwent cardiovascular surgery. Few studies have included non-cardiovascular surgery patients, but similar risk factors have been associated with AKI in this patient group. There are no proven prophylactic interventions during surgery that can protect the kidney damage.[26]

Our study was performed in a very low-risk group for the development of AKI, as it included surgical patients who were excluded from cardiovascular surgery, had a normal renal function, and had no apparent organ dysfunction, vascular pathology, and severe comorbidity. In 38% of patients, creatinine value was increased on the second day compared to baseline. In the linear regression model to find independent variables of second-day creatinine change, ABI, presence of hypertension, RAS blocker use, and duration of operation were found to be independent variables, while age, sex, or presence of diabetes did not show a significant relationship (Table 4).

This study included 26% of the patients who were followed up with the diagnosis of hypertension and approximately 70% of them were using RAS blockers as antihypertensives. It was noteworthy that both hypertension and RAS blocker use were associated with postoperative creatinine elevation. Anesthesia and surgical stress can, directly and indirectly, affect renal function and body fluid regulation. The direct effects of anesthesia are related to the anesthetic agent used and the dose. They affect renal blood flow autoregulation, antidiuretic hormone secretion, and tubular sodium and organic acid transport. They act indirectly through hemodynamic changes, sympathetic activation, and humoral effects. Inhaled anesthetics usually reduce glomerular filtration rate (GFR) and urine output by extrarenal effects.[27]

In the literature, ABI-related studies have mostly focused on patients with peripheral artery disease and cardiovascular disease. These studies have shown that low and high ABI scores are an independent risk indicator for atherosclerotic vascular diseases in these patient groups, are as well as associated with mortality and morbidity.[28-30] In all of these studies, patients with ABI value below 0.9 were also included. However, in our study, there were no patients with an ABI below 0.9. Therefore, there were no patients with peripheral arterial disease or diffuse atherosclerotic vascular disease findings. Thus, our results have confirmed that the use of ABI may be an important indicator in demonstrating postoperative kidney function change.

Hypertension is a traditional major risk factor for atherosclerotic vascular pathologies. Renal vascular structures are one of the primary locations where hypertensive end-organ damage is observed. In addition, atherosclerotic renovascular disease has an important role in peripheral arterial diseases. Hypertension, together with other risk factors, is an important etiologic factor both in the etiology of atherosclerotic renovascular disease and in the development of intrarenal vascular damage (hypertensive nephrosclerosis). ABI is a strong predictor of CVD and a strong predictor of cardiovascular event and mortality.[31] Therefore, it is expected that the group developing AKI will be hypertensive and have low ABI. The creatinine levels of the patients included in our study were within normal limits, and there was no overt proteinuria. The development of postoperative renal dysfunction in hypertensive patients may be indicative of early renovascular damage that has not yet been reflected in laboratory tests, although no significant renal impairment has been detected.

In our study, the duration of the operation has been shown to be an independent risk factor for the development of postoperative AKI. Consistent with this, many studies show that prolonged operation time increases the risk of postoperative AKI.[32,33] There was no relationship between the type of operation applied to our patients and ABI and other laboratory parameters. Acute kidney index was related to the duration of the surgical operation rather than its localization. With the prolongation of the intraoperative period, patients are exposed to the harmful effects of prolonged anesthesia. In this period, hemodynamic instability and hypoxia, which accompany bleeding and fluid losses that do not provide an adequate replacement, cause organ dysfunction, primarily kidney. Prolonged operations are also associated with a greater risk of infection and surgical complications.

On the other hand, groups at high risk for atherosclerotic diseases are also at high risk for renal and renovascular diseases. Endothelial dysfunction may be the most likely cause of this relationship because it plays a major role in the pathogenesis of these two disease groups. Concordantly, in a recent study, endothelial dysfunction and the decrease in kidney function were associated in patients with peripheral artery disease.[30] The relationship between renal dysfunction and ABI, which has recently been considered as a cardiovascular risk parameter, has been investigated further. It has been shown that the prevalence of both microvascular and macrovascular complications increases in diabetic patients with high ABI score, and ABI is associated with macroalbuminuria and chronic kidney disease.[30] The detection of diabetic nephropathy as an independent indicator for severe subclinical peripheral artery disease in a recent study supports the relationship between nephropathy and peripheral artery disease.[34] This relationship is much more evident in advanced kidney disease.[35] In another study, a low ABI score was found to be associated with poor prognosis and all-cause mortality in diabetic kidney patients.[36] These results indicate that the ABI may be a general indicator for all pathologies regarding atherosclerosis and endothelial damage, rather than just a risk indicator for peripheral artery disease (PAD). On the other hand, these studies, which indicate the relationship between kidney damage and ABI, have been studied on patients at high risk for renal and cardiovascular diseases, such as patients with different stages of kidney disease, DM, or proteinuria). The most crucial difference in our study from these studies was that kidney functions in our patients were completely normal (they even had no proteinuria) and ABI levels were normal. That is, they were at low risk for developing renal damage.

In our study, unlike previous studies, no significant correlation was found between advanced age and obesity with AKI.[37,38] The reason why age is not a determining parameter may be the relatively low average age (70% <65 years) and the small number of very older patients in our study. Improvements in perioperative care in recent years (e.g., standard implementation of many preventive measures) may possibly limit the negative impact of obesity-related postoperative complications (lung problems and thromboembolic events) on patient outcomes. Some study results even suggest that obesity may have a protective effect paradoxically.[39]

Postoperative hemoglobin, urea, calcium, albumin, sodium, and potassium variations, which obtained statistically significant results in univariate analyzes but lost their significance in multiple analyzes, may have been affected by the amount and content of hydration in the perioperative period as well as the catabolic effects of the operation. The dilutional effect of hydration may be a partial explanatory factor for the variability of serum solutes. Since these issues are not among the aims of our study, no more detailed interpretation has been made.

There were some limitations in this study: the number of patients was relatively low, and the patients with different types of surgery were included. Therefore, we could not compare the results of the various surgical subgroups extensively. The hourly urine monitoring within 48 hours was not collected, which is important in the diagnosis of AKI. But follow-up of hourly urinary output for 2 days is not required for this kind of patients for 2 days. However, our study also provides some critical contributions to the literature: the BP devices used in our research were uncomplicated devices that can be used easily in routine practice, and our patients were surgical patients with low AKI risk (and therefore they do not require postoperative intensive care) as we frequently encounter in the general population. For such reasons, our results may reflect everyday practice more accurately.

In conclusion, ABI can be used in daily practice as a practical and easy-to-use test in the prediction of renal functional changes and perioperative AKI risk in non-cardiac surgery patient populations, even in patients with no history of peripheral arterial disease. However, these results need to be supported by controlled trials involving more patients with higher and lower ABI values. On the other hand, simple automatic BP measurement devices are easy, inexpensive, and practically applicable to ABI measurement instead of complicated and expensive Doppler devices.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Haseki Training and Research Hospital (Approval Date: December 17, 2014; Approval Number: 170).

Informed Consent: Informed consent was obtained from the participants of the study.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept - A.S., Z.İ., A.H., S.Ö.; Design - A.S., Z.İ., S.Ö.; Supervision - S.K., S.U., E.C., N.Y., M.A.; Resources - S.K., S.U., E.C., N.Y., M.A.; Materials - Z.İ., S.K., S.U., E.C., N.Y.; Data Collection and/or Processing - A.S., Z.İ., M.A.; Analysis and/or Interpretation - A.S., Z.İ., S.Ö.; Literature Review - S.K., S.U., E.C.; Writing - A.S., Z.İ., S.U.; Critical Review - S.U., M.A., S.Ö.

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