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Evaluation of the Effects of Ulnar Artery Flow and Allen's Test on Radial Artery Graft Preference

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ABSTRACT

Objective: This study is to evaluate the efficacy of preoperative and postoperative ulnar arterial flows and preoperative Allen's test in using radial artery graft once coroner bypass surgery.

Material and Method: We retrospectively analyzed the data of 30 patients who underwent coronary bypass surgery and the radial artery was used as a graft. Arterial Doppler ultrasonography was performed before and after coronary bypass surgery, and the preoperative modified Bedford Allen test was applied to all patients preoperatively. A radial artery graft was used all patients. It was understood from the records that the ulnar artery flows in the postoperative period were controlled by Doppler ultrasonography at the 3rd and 6th months. Ulnar artery diameter and flow velocities were compared with preoperative Doppler ultrasonography data.

Results: There was an increase in flow and velocity measurements in ulnar artery after use of radial artery as a graft. The flow of mean ulnar artery increased from 31 ± 21 ml/min to 46 ± 32 ml/min, and the mean speed of ulnar artery increased from 56 ± 19 cm/sec to 78 ± 16 cm/sec ($p <0,005$). Enhanced ulnar artery diameters and flows were detected in the postoperative 3rd and 6th periods of Doppler USG ($p <0.005$). In the postoperative follow up, there was no hand ischemia.

Conclusion: Ulnar artery Doppler ultrasonography and allen testing is a reliable option in coronary bypass surgery to prevent arm ischemia after revascularization with radial artery graft.

Keywords: Cardiac Surgery, Radial Artery, Ulnar Artery, Ischemia.

ÖZET

Ulnar Arter Akımının ve Allen Testinin Radial Arter Greft Tercihine Etkilerinin Değerlendirilmesi

Amaç: Bu araştırma; koroner bypass cerrahisinde preoperatif ve postoperatif ulnar arter akımları ile preoperatif Allen testinin radial arter grefti kullanımındaki etkinliğini değerlendirmektir.

Gereç ve Yöntem: Koroner bypass cerrahisi uygulanan ve radial arterin greft olarak kullanıldığı 30 hastanın verilerini geriye dönük olarak inceledik. Koroner baypas ameliyatı öncesi ve sonrasında arteriyel Doppler ultrasonografi ve tüm hastalara ameliyat öncesi modifiye Bedford Allen testi yapılmıştı. Tüm hastalarda radial arter grefti kullanılmıştı. Postoperatif dönemde ulnar arter akımları 3. ve 6. ayda çekilen doppler ultrasonografi ile değerlendirildi. Ortama ulnar arter çapı ve akım hızları preoperatif doppler ultrasonografi değerleri ile karşılaştırıldı.

Bulgular: Radial greft kullanımı sonrası ulnar arterin akım ve hız ölçümlerinde artış tespit edildi. Ortalama ulnar arter akımı 31 ± 21 ml/dk'dan 46 ± 32 ml/dk'ya, ortalama ulnar arter akım hızı 56 ± 19 cm/sn'den 78 ± 16 cm/sn'ye yükselmişti ($p <0.005$). Çalışma sonucunda postoperatif 3. ve 6. aylarda yapılan Doppler USG'de ulnar arter çap ve akımlarında artış saptandı. Postoperatif takiplerde elde iskemi görülmedi.

Sonuç: Koroner baypas cerrahisinde, radial arter grefti ile revaskülarizasyondan sonra kol iskemisini önlemek için ulnar arter Doppler ultrasonografi ve allen testi güvenilir bir seçenektir.

Anahtar Sözcükler: Kalp Cerrahisi, Radial Arter, Ulnar Arter, İskemi.

Arterial grafts are best choice for coronary bypass, because of their excellent long-term patency. Many surgeons be of the opinion of the radial artery conduit graft as a "reserve" graft, the long-term patency (1, 2). As full arterial revascularization is preferred, more radial artery grafts are required. Another dangerous clinical entity such as radial artery spasm is the development of hand ischemia. Therefore, it is indispensable to evaluate the adequacy of preoperative collateral intake. Different tests and imaging tools are used to evaluate collateral blood flows.

The basis intended in this article the efficacy of preoperative and postoperative ulnar arterial flows and Allen's test in coronary artery revascularization surgery with radial artery.

MATERIAL AND METHOD

This retrospective study has been conducted between March 2015 and April 2018 with 680 indivuduals who

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have undergone cardiac surgery. Only patients that were eligible for isolated coronary operation (n =320) has been enrolled for further analysis. Cases of valvular surgery, aort surgery, prophylactic ıntra-aortic balloon pump usage before coronary vascularization, and coronary vascularization after myocardial infarction has been excluded from the study. All cases of elective coronary surgery has been included in our study.

There were a total of 30 patients who underwent coronary surgery using radial artery graft. We reviewed the collected data after obtaining the necessary ethical approval. (No: 93471371-514.10- D:26.11.2020 -SBÜ Ankara Training and Research Hospital) Those with forearm trauma, diabetic patients, raynaud's syndrome, peripheral artery disease, and smokers were excluded from the study. All demographic characteristics of the patients were recorded (Table 1).

Table 1. *Demographic characteristics of the patients.*

Patients; 30	No. (n)	Percent (%)
Age, mean (years)	67.30	
Sex		
Male	18	60
Female	12	40
HT	12	40
COPD	6	20
Carotid stenosis		
50%	6	20
70%	3	10
Stroke	3	10
Death	0	0
Paresthesia	6	20

HT; Hypertension, COPD; Chronic obstructive pulmonary disease.

Pre and postoperative arterial Doppler ultrasonography was performed in all patients. The brachial artery, radial artery, proximal, distal and middle parts of the ulnar artery, and superficial artery blood flow velocities (cm/sec) and flows were evaluated with a Toshiba Xario (Tokyo-Japan) 7,5-11 Mhz linear -orray transducer device. In the postoperative period, all flows were checked by Doppler USG. The modified Bedford Allen's test was performed on all patients before surgery. Ohmeda GE Handheld Pulse Oximeter device was used for the modified Allen's test. The saturation probe was held in the thumb of the hand always. Flow was evaluated after compression to the arteries. The return of ulnar artery blood flow with pulse oximetry between 6 and 11 seconds was accepted as positive modified Allen test and adequate collateral flow. Thus, it was deemed appropriate to be used as a radial artery conduit graft.

Radial and ulnar blood flows were measured from the medial side of the wrist. Arterial flows were recorded in ml/min. Radial and ulnar artery diameters, flows and velocities were measured by color Doppler USG and recorded. Those with radial artery flow of 20 ml/min and a diameter above 0,20 cm were used as graft.

It was used to evaluate the ulnar collateral activity in the hand for the radial artery by mixing the modified Allen test and oxygen saturation.

Double verification was performed for sufficient collateral flow. The decision was made on the basis of Pulse

Oximeter measurement and Doppler USG. In initial Doppler USG, ulnar and radial flows were normal and radial artery diameter above 0.20 cm was accepted as the first criterion. The second criterion was the measurement of the pulse oximeter between 6-11 seconds. Both negative ones were excluded from the study. Thus, individual mistakes were prevented. Hand flushes were followed during the examination, but it was not considered as an objective parameter.

In the postoperative period, doppler controls were performed in the first 3 months and 6 months and ulnar artery flows were checked. Ischemia and neurological examination for 6 months postoperatively in the hand where the radial artery was grafted.

Statistical analysis

Statistical evaluation of the data was made by transferring it to the SPSS Statistics Base 22.0 version (IBM, USA) statistics program. All data for variables are given as mean ± standard deviation (SD). Descriptive measures of numerical variables were given using Mean±SD. One-sample Kolmogorov-Smirnov test was applied to understand whether the numerical variables of all measurements were normally distributed. "Paired t-test" was applied to understand whether there was a difference between the measurement results before and after the operation. Mean ± SS were used to visualize the analysis results. Statistical $p < 0,05$ values were considered significant in all tests.

RESULTS

The mean RA and UA diameters (cm), flows (ml/min) and velocity media (cm/sec) are presented in table 2.

Table 2. *Doppler ultrasonography of the radial and ulnar artery.*

	Radial artery (main±SD)	Ulnar artery (main±SD)
Diameter (cm)	0,23±0,06 (min-max:0,14-0,31)	0,26±0,02 (min-max:0,21-0,32)
Flow (ml/min)	24±16 (min-max:19,34-41,16)	31±22 (min-max:21,29-53,04)
Flow rate (cm/sec)	47±16 (min-max:31,07-63,16)	56±19 (min-max:36,24-65,07)

Diameter, flow and velocity measurements of RA at wrist level were measured as 0.23±0,06 cm, 24±16 ml/min and 47±16 cm/sec, respectively. The UA was measured as 0.26±0,02 cm, 31±22 ml/min and 56±19 cm/sec.

Flow and velocity measurements in UA were performed by compressing the radial artery. There was an increase in flow and velocity measurements. The flow increased from 31±21 ml/min to 46±32 ml/min, and the speed increased from 56±19 cm/sec to 78±16 cm/sec. In the postoperative 3rd and 6th month Doppler USG, increased ulnar artery diameters and flows were found (Table 3), ($p < 0,005$).

Table 3. *Changes in ulnar artery flow and diameter after 6 months.*

Ulnar artery	Preoperative (main±SD)	Postoperative (main±SD)	p value
Diameter (cm)	0,26±0,02 (min-max:0,21-0,29)	0,29±0,04 (min-max:0,24-0,33)	0,018
Flow (ml/min)	31±22 (min-max:0,9-0,53)	48±12 (min-max:0,34-0,62)	0,012

There was no evidence of ischemia in the upper extremity where the radial artery was removed as a graft at the end of the 6th month. There was no neurological finding. Significant increases in ulnar blood flows occurred in patients who underwent Allen's test and the radial artery had removed as a graft.

DISCUSSION

Today, full arterial revascularization is preferred especially in young patients in coronary bypass surgery. Radial artery graft is the most commonly used free arterial graft after internal mammarian artery graft. The most common problems in using radial artery; ischemia, infection and neurological complications (1).

In order to minimize the complications while obtaining radial artery graft; measurement of ulnar and radial flows with preoperative doppler ultrasonography and Allen's test are widely used. The Allen's test is a simple and reliable method used in the evaluation of the collateral circulation of the hand (2).

Modified Allen's test has been developed to reduce false positive results. We used the Bedford modified Allen's test in our study. If the time to measure resaturation after radial artery compression with pulse oximetry was between 6 and 11 seconds, we evaluated the presence of sufficient collateral flow. We evaluated the measurements of 6 seconds or less as insufficient collateral flow. In the literature, there are studies evaluating less than 5 seconds as complete negativity, while more than 10 seconds positivity (3). Some studies have shown that ulnar artery flows and velocities increased significantly in the second postoperative month (4, 5). We found that ulnar flows increased from 31±22 ml/min to 48±12 ml/min in 6 months. Similarly, we observed an increase in the ulnar artery diameter.

Although the values of UA and RA were close to each other in all tests, an increase was observed in flow (53,1%) and velocity (40,6%) of UA with RA compression. They found insufficiency in ulnar artery velocity in 1,7% with radial artery compression (6). We observed an increase in ulnar artery diameters and flows in the postoperative 3rd and 6th month Doppler USG. In the ulnar artery, the flow increased by 46±32 ml/min and the velocity increased by 78±16 cm/sec (p <0,005). This result demonstrates the presence of compensatory mechanisms. Otherwise, ischemia in the extremity is inevitable. Ulnar artery diameters was detected 0,29±0,04 cm postoperatively (p =0,018).

However, in many studies, it has been reported that the ulnar artery and compensation mechanisms are involved, and ischemia does not develop, and neurological complications such as paresthesia are very rare (7, 8). In our study, we did not find any signs of hand ischemia in any of the 30 patients. No serious neurological complication occurred.

In the preoperative and intraoperative evaluations (Allen's test, Doppler ultrasonography, back flow from intraoperative RA, etc.), cases with hand ischemia and reverse cephalic vein bypass have also been reported, although collateral circulation was sufficient. In addition, accessory RA may be involved. RA may also show anatomical variation at the rate of 9.6%, and this may be most often in the form of tortuous (9-11).

In the study in which radial artery grafts were evaluated for about 20 years, postoperative ulnar flows increased considerably and the plamar digital peak systolic flows confirmed this. In this study, it was reported that there were no symptoms in the upper extremity (12-14).

Limitations of Study

Our study has limitations such as the short-term and limited cases, and the inability to predict arterosclerosis in the ulnar artery, which may develop rapidly later.

Conclusion

The use of the Bedford modified Allen test to control ulnar artery flow may perhaps exclude some cases from the use of this arterial conduit graft unnecessarily. In conclusion, the modified Allen's test and adequate ulnar flows are highly predictive for radial artery graft use.

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