Impact of radial artery sacrifice in hand perfusion

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Abstract

Introduction: Orthopedists get faced with situation where the radial artery needs to be sacrificed, either as donor of vascularized tissue or in situations where it is injured. The aim of this study was to determine morphologic and functional changes in hand circulation after sacrificing the radial artery.
Materials and Methods: We conducted a cross-sectional study by a review of both sexes 41 patients' medical histories subject to myocardial re-vascularization surgery that had undergone removal of the radial artery to be used as graft. Patients were assessed by comparative Doppler bidimensional ultrasound in both limbs, pulse oximetry in both hands' index fingers at rest and under stress, and scintigraphy in both upper limbs at rest and under stress. We verified subjective symptoms and signs related to cold intolerance under stress by exercise. Results were statistically assessed.
Results: Only two patients (4.8%) had claudication symptoms in the hand operated on during intense activity. Comparative assessment between both hands by pulse oximetry and scintigraphy perfusion showed no statistically significant differences. Differences were statistically significant in ultrasound evaluation of both ulnar arteries diameters.
Conclusion: Hand perfusion after sacrificing the radial artery is not altered.

Key words: Flap; radial artery; hand; vascularization.
Level of evidence: IV

Impacto del sacrificio de la arteria radial en la perfusión de la mano

Resumen

Introducción: El ortopedista se enfrenta a situaciones donde impera el sacrificio de la arteria radial, ya sea en el uso del árbol arterial radial como donante de tejido vascularizado o en situaciones donde la arteria radial es lesionada. El objetivo de este estudio fue determinar los cambios morfológicos y funcionales en la circulación de la mano luego del sacrificio de la arteria radial.
Materiales y Métodos: Se realizó un estudio de corte transversal sobre la base de una revisión de historias clínicas de 41 pacientes de ambos sexos, sometidos a cirugía de revascularización miocárdica a quienes se les resecó la arteria radial para ser utilizada como injerto. Los pacientes fueron evaluados mediante ecografía bidimensional y Doppler comparativa de ambos antebrazos, oximetría de pulso del dedo índice de ambas manos en reposo y estrés por ejercicio, y centellografía de ambos miembros superiores en reposo y estrés. Se constataron los síntomas y signos subjetivos de intolerancia al frío y en situación de estrés luego del ejercicio. Los resultados fueron valorados estadísticamente.

Conflict of interests: The authors have reported none.

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Resultados: Solo dos pacientes (4,8%) tuvieron síntomas de claudicación de la mano operada durante actividades intensas. La valoración comparativa de ambas manos por oximetría de pulso y de perfusión por centellografía no arrojó diferencias estadísticamente significativas. La diferencia fue estadísticamente significativa en la medición ecográfica del diámetro de ambas arterias cubitales.
Conclusión: La perfusión de la mano luego del sacrificio de la arteria radial no se ve comprometida.

Palabras clave: Colgajo; arteria radial; mano; vascularización.
Nivel de Evidencia: IV

Introduction

Orthopedists get faced with situations where the radial artery needs to be sacrificed, for both use of the vascular tree of the radial artery as donor of vascularized tissues for coverage of soft tissues defects in reverse circulation flaps (Chinese flap) and situations in which the radial artery is injured and it is decided on radial artery ligation with residual vascularization by the ulnar artery.[1]

The dilemma over the hand being left with a perfusion deficit by these surgical gestures represents a question that can have influence on the decision about sacrificing the vascular tree of the radial artery.[2]

The results of this study can be projected into different situations where perfusion is interrupted at the level of the radial artery (heart/vascular surgery, radial artery injuries, and hand and reconstructive surgery where it is decided to use the radial artery's reverse circulation flap).[2]

We aim at evaluating cost-benefit ratios considering radial artery uses and the hand residual perfusion.

Materials and Methods

We conducted a cross-sectional study by a review of medical histories stored in a database at the Heart Surgery Department at the institution we work at. The study universe were 41 patients of both sexes that had undergone myocardial re-vascularization surgery between 2010 and 2012 and had been subject to removal of the radial artery to be used as graft; they were evaluated at least 6 months after the surgery. We excluded patients with bilateral removal of the radial artery. Patients were asked to consult for checkup to carry out Doppler bidimensional ultrasound comparing both forearms, pulse oximetry with Nonin oximeter 8570 Go2 in both hands' index fingers, at rest and under stress by exercise, what consisted of two-minute fist-opening-and-closing, and scintigraphy in both upper limbs marked with MIBI radioisotopes (technetium radiopharmaceutical) at rest and under stress imposed the same way as just described. Patients were asked about their subjective symptoms and signs of cold intolerance under stress by exercise, and answers were recorded.

We carried out Doppler bidimensional ultrasound to analyze the functional and structural ultrasound characteristics of the ulnar artery in the arm operated on and compared them with those in ulnar artery in the contralateral limb. The study was conducted by an ultrasound specialist with expertise in vascular assessment, with 7.5-12 MHz high-frequency lineal transducer Bi VID General Electric ultrasound scanner,. We made a structural evaluation of the bidimensional image, assessing the width of the artery wall and the diameter of the ulnar artery. Moreover, we made a Doppler ultrasound functional evaluation, assessing the speed of the peak systolic flow comparatively in both forearms. All these data were recorded in an area between 2 and 4 cm proximal to the pisiform bone; the transducer was placed in a (normal to the vase) 90º-± 30° angle trying to spot the characteristics of the pulse peak, with environmental temperature controlled between 23º and 25º.

For scintigraphy we used a Phillip double head gamma chamber and we got 256 x 256 matrix planar images (palmar projection with 20% window). We used a 1.00 zoom and a Lehr-Par collimator (low energy and high resolution).

We injected Technetium 99m-sestamibi 10 mCi at rest and following exercise (stress)—fist-opening-and-closing during 2 minutes; we performed injection only once and carried out two evaluations. Acquisition time was five minutes per-image; we focused on the forearm and the hand. Capturing percentages were assessed using simple rule of three and accounts correction by pixels.

From the statistical point of view, we conducted a descriptive study. The database was made up using Excel Microsoft and the patients' medical histories. We calculated the percentages of the qualitative variables. We applied box-plots to describe the behavior of the quantitative variables and used the t-test to prove the hypothesis about the expectation of the random variable, defined as a difference between the samples averages. The significance level considered for such analysis is lower than 5% ($p<0.05$).

The statistical study was conducted by the t-test method for the following variables: ulnar artery caliber bilateral ratio, ulnar artery width bilateral ratio, hand pulse oximetry bilateral ratio at rest, hand pulse oximetry bilateral ratio under stress, limb perfusion scintigraphy bilateral ratio at rest and under stress.

We registered the patients' comorbidities and risk factors: high blood pressure, dyslipidemia, obesity, smoking, ex smoking, insulin-dependent and non-dependent diabetes, chronic obstructive pulmonary disease, heart attack, peripheral vase disease.

Results

We studied 41 patients (32 males [78%] and 9 females [22%]) ranging from 42 and 75 years old (average 58.5). The time passed between the surgery and the assessment was, on average, 25.8 months (ranging from 7 to 40).

With respect to the patients' risk factors and comorbidities, 33% were smokers; 34%, ex-smokers; 50%, obese; 8% were insulin-dependent diabetics; 40%, insulin-non-dependent diabetics; 5% suffered chronic obstructive pulmonary disease; 28% had suffered heart attack; 83% suffered dyslipemia; 88%, high blood pressure, and 10%, peripheral vase disease.

Medical assessment

Only two (4.8%) among the 41 patients evaluated reported symptoms of cold intolerance (claudication) in the hand operated on during intense exercise; one of them suffered high blood pressure, dyslipema and insulin-non-dependent diabetes; moreover, this patient was obese and an ex-smoker. The other patient suffered high blood pressure and dyslipemia, and was an ex-smoker.

Oximetry assessment

Pulse oximetry in both hands showed similar results both at rest and after exercise. In the arm operated on, oximetry showed a 96.56% average (ranging from 92% to 99%) at rest and a 96.37% average (ranging from 91% and 98%) after exercise.

With respect to the contralateral limb, oximetry averages were 96.59% (ranging from 92% to 99%) at rest and 96.59% (ranging from 93 to 95%) under stress by exercise. None of these four variables showed significant differences.

Ultrasound assessment

The results of the comparative diameter assessment between the two ulnar arteries were: average= 2.86 mm (ranging from 1.7 to 6.21) in the limb operated on and average=2.54 mm (ranging from 1.0 to 3.8) in the contralateral limb. The difference was statistically significant (p=0.0413) (Figure 1).

The average width of the ulnar artery was 0.32 mm (ranging from 0.13 to 0.6) in the limb operated on, and 0.31 mm (ranging from 0.1 to 0.8) in the contralateral limb. The difference was not statistically significant (p=0.0413) (Figure 1).

The peak systolic flow as evaluated by Doppler ultrasound in the ulnar artery averaged 58.27 cm/s (ranging from 30 to 91) in the limb operated on, and 52.45 cm/s (ranging from 23.7 to 78) in the contralateral limb, a difference that was statistically significant too (p=0.0361) (Figure 2).

Perfusion assessment by scintigraphy

Perfusion assessment by gamma chamber showed the following data: average capture=91% (ranging from 77% and 96%) in the limb operated on and 91.37% (ranging

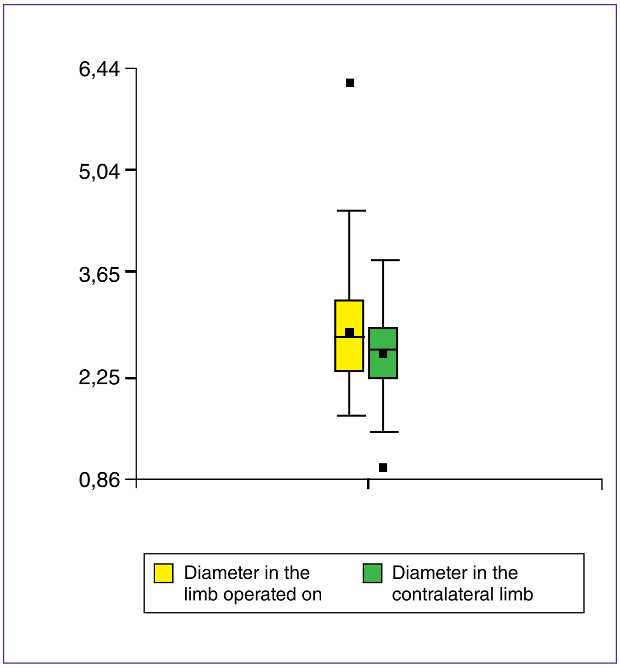

Figure 1. Evaluation of the ulnar artery diameter in both limbs.

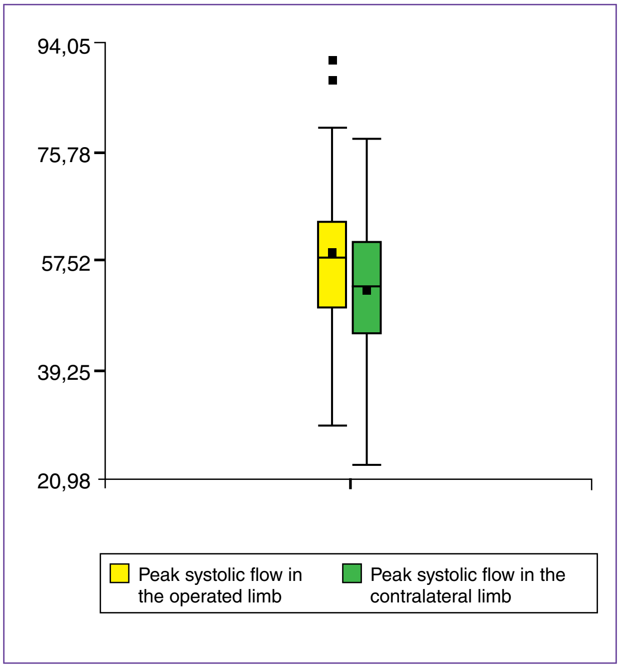

Figura 2. Evaluation of the peak systolic flow.

from 77% and 97%) in the contralateral limb, both at rest. Average capture was 85.15% (ranging from 61% to 95%) in the limb operated on and 85.59% (ranging from 59% and 98%) in the contralateral limb, both under stress by exercise, with differences non-statistically significant (Table).

Discussion

In reconstructive surgery of the upper limb, the radial artery comes to the forefront when it is part of the problem (isolated injury of the artery) or when it is part of the potential solution (Chinese flap). Techniques of microsurgical vase anastomosis have gained popularity and are available for an increasing number of surgeons; this leads to an increase in treatment offers when it comes to limbs defects reconstruction. However, surgical procedures that once revolutionized reconstructive surgery of the limbs, such as the radial artery reverse flap, today are put into question due to the vascular axis sacrifice and the blood supply deficit this could cause.[2]

Higgins[2] balances pros and cons of this flap, predictability of the procedure vs. the morbidity it causes, and is based mainly on papers published by Heart Surgery Departments or similar ones, where they use the radial artery as graft for the reconstruction of the coronary artery.

Yumiko et al.[3] conclude that there are differences in blood pressure and flow assessed in the index finger of the donor hand as compared to those in the contralateral hand while lifting the Chinese flap in the two first months following the surgery, and they return to normal after the year; therefore, we designed this study in patients who were deprived from perfusion out of the radial artery, evaluating them 6 months after the surgery. Brodman et al.[4] carried out a pre- and post-operative study during the first eight weeks after getting the radial artery as graft for coronary re-vascularization, and concluded that perfusion increases out of the ulnar artery, which increases in both diameter and flow. Although the thumb perfusion rates decrease during the first eight weeks, this does not imply ischemia. Manabe et al. [5,6] collected interesting data about pre-operative decision-making so as to predict potential problems in hand perfusion, and they highlight working and entertaining activities the patient will develop after the surgery. The authors conclude that <1.4mm/m^2 diameter and <60ml/min/m^2 flow in the ulnar artery, assessed at wrist level, suggest risk of intolerance under stress by exercise.

In a series of 16 patients subject to radial artery sacrifice for graft in coronary re-vascularization surgery, Royse et al.[7] compared perfusion by the ulnar artery in the limb operated on with the ulnar artery in the contralateral limb before compression of the radial artery, and evaluated diameters and flows in brachial and ulnar arteries at rest and under stress. They reported that, although flow increased in both ulnar arteries, the artery diameter proved wider in the limb operated on, but it did not in the contralateral limb; there were differences neither in diameter nor in flow in brachial arteries at rest and under stress. They concluded that flow in the forearms and the hand was not affected by the dissection of the radial artery. Another advantage of the use of the vascular tree of the radial artery is the conclusion they draw in another publication[8] which reports the absence of atheromatous plaque and preservation of flow in both the forearm and the hand after an average follow-up of eight years.

With respect to the changes in hand perfusion in association with exercise after sacrificing the radial artery, Manabe et al. [5,6] report 12.5% of patients with symptoms of moderate ischemia under these circumstances; in our series, this percentage was 4.8% representing two isolated patients whose symptoms were mild and occasional.

Given the data we present and the results we got in this study, we believe that hand perfusion after radial artery sacrifice is not significantly altered; we believe it is necessary to assess the caliber of the ulnar artery and consider the patient's activities, because small diameters imply higher probabilities of suffering symptoms related to ischemia while using the limb moderately. There are

Table. Statistical comparison between variables in both hands

Variables	Hand operated on	Contralateral hand	p
Oximetry in the limb at rest	96.56	96.59	0.9439
Oximetry in the limb under stress	96.37	96.59	0.562
Diameter of the ulnar artery	2.86	2.54	0.0413
Width of the ulnar artery	0.32	0.31	0.6757
Peak systolic flow in the ulnar artery	58.27	52.45	0.0361
Scintigraphy at rest	91	91.37	0.6999
Scintigraphy under stress	85.15	85.59	0.8035

patients who report symptoms of claudication while doing exercise, but the percentage is low. Both our study and the bibliography we consulted prove that forearm and hand perfusion is not affected by radial artery sacrifice.

Conclusions

On the basis of the global results of medical, ultrasound, Doppler bidimemsional, oximetry and scintigraphy perfusion studies, all at rest and under stress, it was proved that differences are statistically significant only in peak systolic flow and ulnar artery diameter in the limb operated on when compared with the contralateral limb after sacrificing the radial artery. Our results coincide with the data reported by the bibliography that we consulted.

Therefore, we conclude that hand perfusion after radial artery sacrifice is not altered.

Bibliography

1. Gang RK. The Chinese forearm flap in reconstruction of the hand**.** *J Hand Surg Br* 1990;15(1):84-88.
2. Higgins JP. A reassessment of the role of the radial forearm flap in upper extremity reconstruction. *J Hand Surg Am* 2011;36: 1237-1240.
3. Yumiko I, Tsutomu N, Keisuke M, Hiroshi H, Nobuhisa T, Akiyoshi K. Hemodynamic changes of the hand after radial forearm flap harvesting. *Ann Plast Surg* 2002;49(2):156-160.
4. Brodman R, Hirsh L, Frame L. Effect of radial artery harvest on collateral forearm blood flow and digital perfusion. *J Thorac Cardiovasc Surg* 2002;123:512-516.
5. Manabe S, Tabuchi N, Toyama M, Yoshizaki T, Kato M, Wu H, et al. Oxygen pressure measurement during grip exercise reveals exercise intolerance after radial harvest. *Ann Thorac Surg* 2004;77(6):2066-2070.
6. Manabe N, Tabuchi M, Toyama K, Kuriu1 T, Mizuno M, Sunamori M. Measurement of ulnar flow is helpful in predicting ischemia after radial artery harvest*.* *Thorac Cardiovasc Surg* 2002;50(6):325-328.
7. Royse A, Royse C, Maleskar A, Garg A. Harvest of the radial artery for coronary artery surgery preserves maximal blood flow of the forearm. *Ann Thorac Surg* 2004;78(2):539-542.
8. Royse AG, Chang GS, Nicholas DM, Royse CF. No late ulnar artery atheroma after radial artery harvest for coronary artery bypass surgery. *Ann Thorac Surg* 2008;85(3):891-894.