MODIFICATIONS OF ARTERIAL BLOOD FLOW TO THE HAND AFTER CARPAL TUNNEL RELEASE

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Any surgical procedure is followed by an inflammatory reaction, associated with arteriolar dilatation and increased capillary permeability. The normal evolution is in most cases a progressive decrease of the inflammatory signs. Some patients however, particularly after orthopedic trauma affecting the extremities, develop algodystrophy, initially characterized by arterial vasodilatation and low capillary flow. In an effort to better understand the normal phenomena seen after uncomplicated hand surgery, the authors have evaluated the postoperative arterial blood flow using the Duplex flowmetry ultrasound technique in 13 patients operated for carpal tunnel syndrome, who did not subsequently develop algodystrophy. After measurement of the transverse section of the ulnar and radial arteries, and longitudinal measurement of the mean velocimetry, the arterial blood flow was calculated. The measurements were done 1, 2 and 4 weeks after the operative procedure. The study demonstrated a moderate (15% - 30%) but significant increase in the arterial blood flow to the hand, related to arterial dilatation of the vessels and to an increase in blood velocimetry.

Keywords : algodystrophy ; reflex sympathetic dystrophy ; carpal tunnel syndrome ; Duplex.
Mots-clés : algodystrophie ; dystrophie réflexe sympathique ; syndrome du tunnel carpien ; Duplex.

INTRODUCTION

Any surgical procedure is followed by an inflammatory reaction. The first vasomotor response is caused by a normal sympathetic reflex and consists in transient vasoconstriction (20, 30). Shortly after this initial phase, the response to tissue injury is increased arteriolar dilatation and permeability, with subsequent edema, related to the local release of mediators such as substance P and histamine (6, 7, 10, 13, 21). Neutrophils migrate within the inflamed zone and produce a plasmin activator, with the formation of bradykinin. Bradykinin release results in the production of numerous other vasoactive agents, producing further capillary permeability and further neutrophil activity, with release of more bradykinin. This is the classical inflammatory reaction seen after any trauma, and clinically characterized by pain, increased temperature, redness, edema, and progressive stiffening of the joints. The normal evolution is in most cases a progressive decrease in the inflammatory signs, with return of normal function. Some patients, however, particularly after orthopedic trauma or surgical procedures affecting the extremities — hands or feet — develop algodystrophy.

Algodystrophy is now believed to be an exaggerated regional inflammatory disorder, as sug-

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gested initially by Sudeck (1). Algodystrophy is initially characterized by arterial vasodilatation, precapillary arteriovenous shunting, low capillary flow, increased venous pressure, inappropriate vasomotor responses, and persistent stimulation of nociceptors (26). These changes have been clearly demonstrated by various techniques, including strain-gauge plethysmography (3, 4, 9, 12, 22, 28), 3-phase bone scanning (11, 15, 18, 24, 26), finger-pulp infrared photoplethysmography (7), pulp laser Doppler flowmetry (7), capillaroscopy (23), xenon wash-out technique (4), Duplex ultrasound measurements (29), and thermography (1, 5-8, 14, 16, 17, 20, 27).

If one wishes to relate these vascular abnormalities to the development of algodystrophy, it is important to appreciate the actual postoperative modifications of blood flow to the hand, particularly in patients not developing algodystrophy. In a previous study, we have performed a 3-phase bone scan in 20 patients, operated at the hand for various indications, and who did not subsequently develop algodystrophy. Marked red blood cells were used for the first two phases, in order to evaluate precisely the sole vascular compartment (24, 30). A postoperative increase in blood flow was observed in 80%, and in blood pool, in 75% (24).

The aims of the present study were to measure the normal changes in postoperative arterial blood flow during the first operative weeks after a conventional surgical procedure at the wrist, i.e. carpal tunnel release.

MATERIALS AND METHODS

Thirteen patients (6 men, 7 women, mean age 48 years, median age 47 years, range 25 to 77 years) operated for EMG-proven (mean distal motor latency 5.2 msec., median 4.8 msec., range 4 to 7.7 msec.) carpal tunnel syndrome, either by conventional (5 cases) or endoscopic (Agee protocol, 8 cases) technique, agreed to participate in the following experimental protocol, previously approved by the ethical committee of our University Hospital. All patients were operated under regional anesthesia. In all 13 patients, the postoperative evolution was very satisfactory, without complications including algodystrophy, and with disappearance of the preoperative dysesthesias.

The arterial blood flow to the hand was studied using the color Duplex flowmetry technique. Basically, the Duplex transducer emits and then receives and processes ultrasound amplitudes reflected from various structures within the object being scanned. A shift in frequency between the emitted ultrasound and the received echo corresponds to a moving object, causing a Doppler shift. Because red blood cells are essentially the only moving objects, the technique allows the precise delineation of the vessels and measurement of the flow velocimetry (19).

The measurements were done at constant room temperature (24°), one week, two weeks and four weeks after the operative procedure. After measurement of the transverse section of the ulnar and radial arteries at the distal forearm, and longitudinal measurement of the mean arterial velocimetry along each artery, the arterial blood flow to the hand was calculated. Each set of measurements was done at least 3 times, and the values were averaged.

The reproducibility of the measurements was within 0.4 mm^2 (surface of the vessel) and 0.04 m/sec. (velocimetry). The reproducibility of the measurements over time was evaluated in a nonoperated normal individual: the mean coefficient of variation (SD/mean) from one week to the next was 0.8%.

RESULTS

On the *nonoperative side*, the surface of the ulnar artery averaged 5.6 mm^2 (S.D. 2.6 mm^2), and the surface of the radial artery, 5.7 mm^2 (S.D. 1.9 mm^2). The mean velocimetry along the ulnar artery was 0.26 m/sec. (S.D. 0.09 m/sec.), and along the radial artery, 0.25 m/sec. (S.D. 0.09 m/sec.). The mean calculated arterial blood flow was 96.8 cc/min. (S.D. 68.4 cc/min.) through the ulnar artery, and 89.8 cc/min. (S.D. 55.5 cc/min.) through the radial artery. Table I presents the results on the *operated side*, expressed in percent of the measurement of the normal nonoperated side. There was in most patients a moderate arterial vasodilatation, characterized by an increase of the surface of the vessel, and some increase in velocimetry. These phenomena resulted in an increase of arterial blood flow, particularly within the radial artery, in the postoperative period. The differences were significant for the surface and arterial flow of the radial artery, two weeks after

Table I. — Results, operated side (in % of the normal contralateral side)

	Surface, ulnar artery	Surface, radial artery	Velocimetry, ulnar artery	Velocimetry, radial artery	Arterial flow, ulnar artery	Arterial flow, radial artery
1 week	101.4 ± 22.4	113.2 ± 25.3	112.1 ± 35.9	112.1 ± 32.5	120.0 ± 60.4	128.3 ± 48.9
2 weeks	108.5 ± 30.2	115.9 ± 19.7 **	102.7 ± 22.7	106.9 ± 22.7	117.8 ± 42.5	124.2 ± 34.0 *
3 weeks	100.9 ± 29.6	110.1 ± 25.5	99.1 ± 21.2	117.8 ± 29.9	107.6 ± 50.1	134.2 ± 57.00

(* $p < 0.05$; ** $p < 0.01$)

the surgical procedure. No significant difference was found according to the type of surgical procedure performed (open or endoscopic section of the flexor retinaculum).

DISCUSSION

This study demonstrates that in the first postoperative weeks following hand surgery, in patients not developing algodystrophy, there is a moderate increase of arterial blood flow to the hand, related to an arterial dilatation of the vessels and to an increase of blood velocimetry.

The vascular changes were moderate after carpal tunnel release. It may well be that the increase in arterial blood flow is greater in other clinical situations, for example in the case of a distal radius fracture.

The common opinion that the diameter of the artery remains an anatomical constant (2) was not confirmed by our findings. The postoperative increase of arterial blood flow may have important clinical implications, in particular considering the prevention of algodystrophy (25, 26). We believe that algodystrophy may be prevented in most patients by minimizing the normal postoperative inflammation, by increasing the venous return (avoiding plaster casts and constrictive dressings is especially important), by controlling the post-traumatic pain, by promoting early active mobilization, and by reassurance of the patient (26).

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SAMENVATTING

F. SCHUIND, T. NGUYEN, M. VANCABEKE, J. Cl. WAUTRECHT. Verandering van het arterieel bloeddebiet van de hand na decompressie van de carpale tunnel.

Elke chirurgische operatie is gevolgd door een inflammatoire reactie, met een vasodilatatie van de kleine slagaders en een verhoging van de doorlaatbaarheid bij de haarvaatjes. Normalerwijs verdwijnt deze inflammatoire reactie geleidelijk. Bij sommige patiënten zien wij na een trauma een algodystrofie aan de hand of voet ontstaan, met vasodilatatie van de slagaders en een vertraging van het bloeddebiet van de haarvaatjes. Om beter het normale verloop te begrijpen na handoperatie zonder komplikatie hebben de auteurs een evaluatie van het postoperative arterieel bloeddebiet gemeten (met de Duplex techniek) bij 13 patiënten geopereerd van de carpale tunnel en die geen algodystrofie ontwikkeld hebben. Na metingen van de transverse diameter van de ulnaire en radiale slagaders, en van de longitudinale gemiddelde velokimetrie, werd het arterieel bloeddebiet uitgerekend. De metingen werden uitgevoerd een, twee en vier weken na de operatie. De studie heeft een lichte maar significante (15 - 30%) verhoging van het arterieel bloeddebiet aan de hand aangetoond, door een arteriële vasodilatatie en een verhoging van de bloed velokimetrie.

RÉSUMÉ

F. SCHUIND, T. NGUYEN, M. VANCABEKE, J. Cl. WAUTRECHT. Modification du débit sanguin artériel à la main après libération du tunnel carpien.

Toute intervention chirurgicale est suivie d'une réaction inflammatoire, caractérisée par une vasodilatation artériolaire et une augmentation de la perméabilité au niveau capillaire. Normalement, cette réaction inflammatoire est progressivement résolutive. Certains patients toutefois, en particulier après traumatisme orthopédique touchant une extrémité, développent une algodystro-

phie, initialement caractérisée par une vasodilatation artérielle et un ralentissement du flux sanguin capillaire. Dans le but de mieux appréhender les phénomènes normaux, observés après chirurgie non compliquée de la main, les auteurs ont évalué le débit sanguin artériel postopératoire à l'aide de la technique Duplex, chez 13 patients opérés pour syndrome du tunnel carpien et n'ayant pas ultérieurement développé d'algodystrophie. Après mesure de la surface transversale des artères ulnaire et radiale, et de la vélocimétrie moyenne longitudinale, le débit sanguin artériel a été calculé. Les mesures ont été réalisées une, deux et quatre semaines après l'intervention chirurgicale. L'étude a démontré une augmentation modérée (15 à 30%) mais significative du débit sanguin artériel à la main, liée à une vasodilatation artérielle et à une augmentation de la vélocimétrie sanguine.