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Skeletonization of the internal thoracic artery: a randomized comparison of harvesting methods

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Abstract

We performed a randomized study to compare internal thoracic artery (ITA) flow response to two harvesting methods used in the skeletonization procedure: ultrasonic scalpel and bipolar electrocautery. Sixty patients scheduled for CABG were randomized to receive either ultrasonically ($n=30$ patients) or electrocautery ($n=30$ patients) skeletonized ITAs. Intraoperative ITA graft mean flows were obtained with a transit-time flowmeter. ITA flows were evaluated at the beginning (Time 1) and at the end (Time 2) of the harvesting procedure. Post-cardiopulmonary bypass (CPB) flow measurement (Time 3) was obtained in the ITA grafts anastomosed to the left anterior descending artery. Intraoperative mean flow decreased significantly within ultrasonic group (Group U) and electrocautery group (Group E) at the end of the harvesting procedure ($P<0.0001$ in both cases). Within both groups the final mean flow measured on anastomosed ITAs (Time 3) was significantly higher than the beginning ITA flow value (Time 1). No statistical difference was noted comparing ITA flows between the two groups at any time of evaluation. Skeletonization harvesting of the ITA produces a modification of the mean flow. The quantity and the reversibility of this phenomenon, probably related to vasospasm, are independent from the energy source used in the skeletonization procedure.

1. Introduction

Internal thoracic arteries (ITAs) are the gold standard among vascular grafts in coronary artery bypass [1]. Skeletonized ITAs are reported to be associated with some benefits compared with pedicled ITAs [2]. Nonetheless, reasonable doubts remain about mechanical mediated vasospasm phenomena hypothetically associated with a more invasive procedure. Equally, some have raised concerns about thermal mediated vasospasm with the use of electrocautery for skeletonization, and so an alternative harvesting technique with an ultrasonic scalpel has been advocated [3].

The purpose of this study was to evaluate if ultrasound skeletonization of the ITA has a lesser effect on the graft flow than skeletonization carried out by conventional bipolar electrocautery.

2. Material and methods

The present study is a single-center, prospective, randomized analysis. It was approved by the Local Ethics Committee and informed consent was obtained from the patients. Sixty consecutive patients undergoing isolated on-pump CABG requiring ITA harvest by one participating surgeon

(L.A.) were included in the study. Exclusion criteria were no elective surgery, intraoperative requirement of vasoactive drugs, and ITA used for sequential grafting (Fig. 1). Patients were randomly allocated to receive as ITA skeletonization method, either bipolar electrocautery (Group E) or ultrasonic scalpel (Group U). Randomization was achieved drawing pieces of paper assigning the skeletonization procedure (30 indicating electrocautery, 30 indicating ultrasonic scalpel) from an opaque bag. There was no significant difference in the clinical characteristics of the two patient groups, including gender, age, height, weight, body mass index, incidence of left main coronary artery disease, peripheral vascular disease, diabetes mellitus, hypercholesterolemia, smoking history, and preoperative use of cardioactive drugs (Table 1). In all patients the left ITA was anastomosed to the left anterior descending artery (LAD).

2.1. Operative protocol

In all patients the left ITA was harvested from the first rib to the ITA bifurcation. The endothoracic fascia was incised longitudinally and laterally to the medial satellite vein using a bipolar electrocautery at low setting (level 4 out of 10) in group E (KLS martin MEMB1, Gebrüder Martin, Tuttlingen, Germany) and an ultrasonic scalpel in group U (Harmonic Scalpel, Ethicon Endo-Surgery, Cincinnati, OH). The space between the medial satellite vein and the ITA

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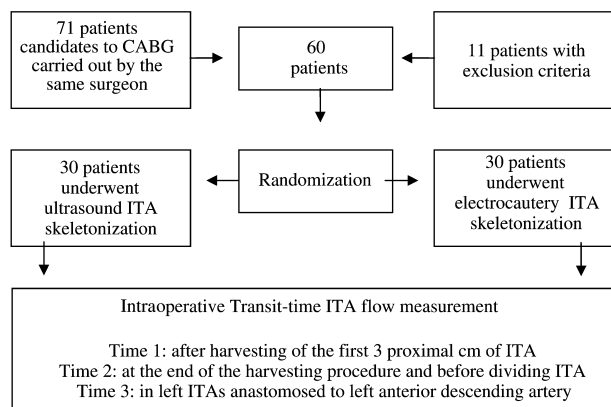*E-mail address:* stefano_urso@inwind.it (S. Urso).

Fig. 1. The study protocol.

Table 1
Preoperative data

Patient characteristics	Group E (n=30)	Group U (n=30)	P-values
Male	83.3% (25)	80% (25)	1
Age (years)	66.3±9.5	62.9±11.3	0.2
Weight (kg)	81±13.3	79±14.1	0.6
Height (cm)	167.3±7.0	167.7	0.8
BMI	28.92±3.9	28.26±4.6	0.5
Left main disease	26.6% (8)	30% (9)	1
Peripheral vascular disease	6.6% (2)	13.3% (4)	0.6
Diabetes mellitus	26.6% (8)	33.3% (10)	0.7
Hypercholesterolemia	26.6% (8)	33.3% (10)	0.7
Smoking history	33.3% (10)	43.3% (13)	0.5
Beta-blocker	40% (12)	56.6% (17)	0.3
Calcium antagonist	23.3% (7)	20% (6)	1
AECI	53.3% (16)	43.3% (13)	0.6

AECI, angiotensin converter enzyme inhibitor; BMI, body mass index.

was carefully dissected by the respective instrument's blade exposing the lateral branches. Proximally, the artery branches were ligated with vascular clips. Distally, in group E they were coagulated and divided diathermically. In group U they were coagulated ultrasonically at least 2 mm from the trunk. The ultrasonic coagulation was continued for 4 s for each branch (output 2). In both groups lateral tributaries with a diameter >3 mm were clipped and divided by surgical scissors. After systemic heparinization the distal end of the ITA was divided and prepared for 7-0 polypropylene suture anastomosis. In no case was papaverin solution applied to the ITA.

2.2. Intraoperative transit-time flow measurement

Intraoperative flow measurements were achieved by a transit-time flowmeter (TTF) (CardioMed, Medi-Stim, Norway). TTF parameters used in this study were: mean flow calculated across 5 cardiac cycles (Q mean), and pulsatility index (PI): (maximum flow recorded in 1 cardiac cycle – minimum flow recorded through 1 cardiac cycle)/ Q mean. ITA flow was measured three times. Time 1: after harvesting of the first three proximal centimeters of ITA. Time 2: at the end of the harvesting procedure and before dividing ITA. Time 3: on the anastomosed ITA once the extracorporeal circulation had been terminated. All three measurements were carried out off-pump, maintaining a

systolic arterial pressure between 130 and 100 mmHg and a diastolic arterial pressure between 70 and 40 mmHg. All measurements were performed placing a 2 or 3 mm TTF probe around the proximal third of the skeletonized ITA.

2.3. Statistical analysis

A pilot study was carried out to assess the minimum sample size to detect an absolute flow difference of 10 ml/min between ITAs harvested by bipolar electrocautery and ITAs harvested by ultrasonic scalpel. Ten ITAs for each method were measured with a transit-time flowmeter after the harvesting of the first proximal 3 cm. Mean flow of electric harvested ITAs and of ultrasound harvested ITAs were 19.11±9.7 ml and 20.8±12.8 ml, respectively. At a two-sided α level of 0.05 and 90% power, 28 pairs of ITAs were the minimal required sample. A final sample size of 60 ITAs was then used.

Continuous variables following a normal distribution according to Kolmogorov–Smirnov test were expressed as mean±S.D. (ITA mean flow values, age, weight, height and BMI). Continuous variables not normally distributed were expressed as median with 10th and 90th percentiles (pulsatility index values). Categorical variables were expressed as percentage and absolute frequencies and were analyzed with the two-tailed Fisher's exact test. The Student t-test for independent samples was used for normal continuous variables to analyze statistical difference between and among the two groups. Welch test correction was used for unequal variance between groups. The Mann–Whitney test was used for not normally distributed continuous variables. A P-value of <0.05 was considered to be statistically significant. Statistical analyses were performed using MedCalc® for Windows, version 9.2.1.0 (MedCalc Software, Mariakerke, Belgium).

3. Results

ITA harvesting procedure was successfully carried out in all patients. We did not appreciate macroscopic differences of ITA between the two groups. Intraoperative flow values are listed in Table 2. We did not find any statistical difference comparing ITAs mean flows between the two groups at any time of evaluation. Also, a non-significant difference was detected analyzing the pulsatility index of ITAs harvested according to the two compared methods.

Within each group ITA mean flow decreased significantly from the beginning (Time 1) to the end of the harvesting

Table 2
Intraoperative measurements

Flow ITA parameters	Group E (n=30)	Group U (n=30)	P-values
Q mean T1 (ml/min)	17.7±9.1	18.5±10.8	0.7
Q mean T2 (ml/min)	3.9±7.9	3.4±7.2	0.7
Q mean T3 (ml/min)	26.0±16.8	25.8±16.3	1
PI T1	4.3 (2.5–10.3)	3.9 (2.4–13.5)	0.6
PI T2	6.0 (2.1–29.8)	6.4 (2.2–30.2)	0.7
PI T3	2.5 (1.4–5.3)	2.6 (1.5–5.4)	0.5

ITA mean flow values (Q mean) and pulsatility index values (PI) at the beginning (T1) and at the end (T2) of the harvesting procedure, and in anastomosed ITAs (T3).
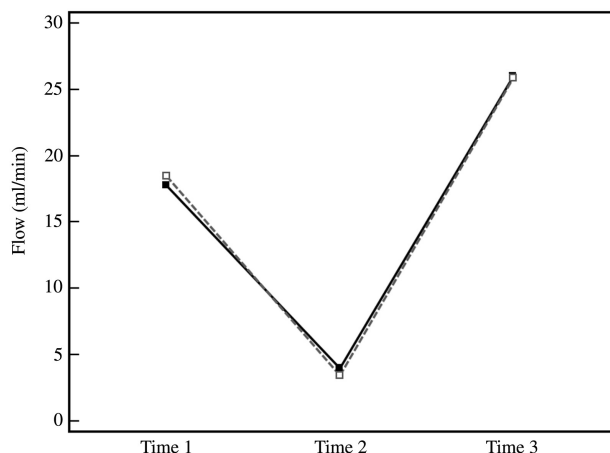
Fig. 2. Intraoperative ITA mean flow valued at the beginning (Time 1) and at the end (Time 2) of the harvesting procedure, and in anastomosed ITAs (Time 3). Continuous line: Group E. Dotted line: Group U.

procedure (Time 2). The mean flow decrement in Group E was 13.8 ml/min (95% CI of difference 18.2–9.3 ml/min, $P<0.0001$). The mean flow decrement in Group U was 15.0 ml/min (95% CI of difference 19.8–10.2 ml/min $P<0.0001$). Within both groups the final main flow measured on anastomosed ITAs to LAD (Time 3) was significantly higher than the beginning ITA flow value (Time1). The mean flow increment in Group E was 8.2 ml/min (95% CI of difference 1.2–15.2 ml/min, P 0.02). The mean flow increment in Group U was 7.3 ml/min (95% CI of difference 0.1–14.5 ml/min, P 0.04). Mean ITA flow variations over the three measurement times describe a 'V' shape curve (Fig. 2).

4. Discussion

The skeletonization of the internal thoracic artery (ITA) was first reported by Keely in 1987 [4]. The expansion in the use of skeletonized mammary artery in coronary artery bypass grafting was founded on studies reporting the effect of harvesting pedicled ITAs on the vasculature and blood supply to the sternum. Skeletonization of the ITA allows ligation of lateral branches as close as possible to the ITA itself. This is a surgical maneuver that has been shown to preserve collateral blood flow to the sternum [5]. Most reports have suggested that in fact there is an associated increase in sternal wound infection and dehiscence, mainly in patients with diabetes [6]. The use of techniques for skeletonizing the ITAs during preparation, thus minimizing the decrement in sternal blood supply, may decrease the incidence of sternal complications [7].

Apart from the benefits on sternal vascularity and sternotomy wound complications, the skeletonization of the ITAs has shown other advantages. Calafiore et al. [8] demonstrated that the length of the skeletonized conduit is greater than that of the pedicled with a mean difference in length of 3.7 cm, 10 min after the application of papaverine. Similarly, preparation of the ITA with the skeletonization technique results in significantly higher free flow capacity than in pedicled grafts [9]. Benefits in terms of sternotomy wound pain and dysesthesia have also been demonstrated in a randomized study [2].

Although some have expressed concerns about the functional consequences of surgical trauma, and the possible loss of innervation and vasa vasorum perfusion in the skeletonized conduits [10], a number of reports have shown no difference in postoperative vasoreactivity, and functional integrity [11].

The patency rate of skeletonised ITAs has been the subject of several reports. In the abscence of randomized trials, observational studies have shown short- and mid-term patency rates of skeletonized ITAs comparable to those of not-skeletonized grafts [8].

The harmonic scalpel uses ultrasonic energy to cut and coagulate tissues at the same time. It controls bleeding by coaptive coagulation at low temperatures ranging from 50 °C to 100 °C. Coagulation occurs by means of protein denaturation when the blade, vibrating at 55,500 Hz, couples with protein, denaturing it to form a coagulum. Therefore, it has been suggested that it produces minimal lateral thermal tissue damage [3].

Vasospasm of arterial conduits is an important cause of graft failure and morbidity in patients undergoing coronary artery surgery. The etiology of graft vasospasm is likely to be multifactorial, including trauma at the time of surgery, endothelial disruption and the presence of vasoactive substances [12].

Orejola et al. carried out a non-randomized study on 20 consecutive patients assessing the effect of the harmonic scalpel and electrocautery on pedicled ITA flow [13]. Although the number of patients enrolled in the study was low, they found no difference between both methods. To our knowledge, there are no randomized trials comparing the effect of electrocautery and the ultrasonic scalpel on ITA flow.

In our study, we used transit-time flowmetry to measure flow across the ITA. This technique is based on the principle of transit-time ultrasound technology. It uses a flow probe, which holds the graft perpendicular to two ultrasonic transducers and a fixed acoustic reflector housed within the probe. The ultrasound pulse signals transmitted from the transducers propagate both upstream and downstream of the direction of blood flow through the reflector. The integrated transit time that measures the difference between the duration taken for signal travel between the two transducers is used to provide a precise measure of flow volume. It has been validated for its use in the assessment of coronary artery bypass grafts [14] and has been used in comparable studies [13, 15].

We measured flow across the ITA at three different times, at the initiation of the harvesting procedure, at the end of this procedure and once the anastomosis had been constructed and the extracorporeal circulation had terminated. We were unable to demonstrate a significant difference in flow between the two techniques at any point in time. Interestingly, we found an increase in ITA graft flow once these had been anastomosed to the LAD. Although comparisons with pre-bypass measurements are not pertinent because of the different flow conditions, the finding suggests that any possible manipulation related spasm is reversible. We therefore conclude that although the handling of the ITA during the harvesting produces a reduction of ITA flow presumably due to spasm, this is independent

of the technique used for skeletonization and appears to be reversible.

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