Decreased sternal vascularity after internal thoracic artery harvesting resolves with time: An assessment with single photon emission computed tomography

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Objective: We sought to prospectively evaluate the long-term effect of left internal thoracic artery harvesting on sternal vascularity.

Methods: Twelve consecutive patients undergoing primary coronary artery bypass grafting were studied. In all patients a pedicled left internal thoracic artery was harvested. Each patient underwent a preoperative technetium-99m methylene diphosphonate bone scan with single photon emission computed tomography. The ratio of the mean counts per pixel for each side of the sternum was obtained. All patients had early repeat bone scans 6 ± 2.4 days postoperatively and late repeat bone scans 18.6 ± 3.5 months after the operation. Ratios of unilateral sternal uptakes were compared between the different scans. One patient died during follow-up and was excluded from the study.

Results: There was a significant decrease in flow to the left hemisternum in the early postoperative scan compared with that in the preoperative scan ($P < .001$). At late follow-up scans, flow to the left hemisternum had returned to normal ($P = .119$). Midterm clinical follow-up demonstrated 3 superficial wound infections. No musculoskeletal pain existed at the time of follow-up, but 3 patients had numbness or tingling at the skin area corresponding to the site from which the left internal thoracic artery was harvested.

Conclusions: Acute postoperative sternal ischemia caused by harvesting of a pedicled left internal thoracic artery is temporary and resolves with time.

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Both experimental and clinical data have shown that harvesting a pedicled internal thoracic artery (ITA) results in acute sternal ischemia.¹⁻³ Experimental animal studies have shown that acute sternal ischemia resolves over time.⁴ Whether the same phenomenon occurs in patients is unknown. The purpose of this study was to evaluate the sternal vascularity over time in patients with documented sternal ischemia after coronary artery bypass grafting (CABG).

TABLE 1. Midterm clinical follow-up

Variables	No. occurred
Readmissions	5
Cardiac	1
Respiratory	1
Superficial wound infection	3
Numbness and tingling	3
Pain with breathing	0
Pain on palpation	0

Patients and Methods

The study group comprised 12 patients who underwent CABG with a pedicled left ITA (LITA) without harvest of the right ITA. The LITA was harvested with a 2-cm pedicle, including muscle and fascia. The majority of the dissection was done with the aid of cautery. Individual branches of the ITA were controlled with clips. Hemostasis of the LITA bed was performed with cautery. The sternum was closed with individual steel wires.

Preoperative demographic data, cardiac risk factors, and subsystems were evaluated for each patient, as well as intraoperative variables. Operative data collected included bypass time, cross-clamp time, and number of grafts. The postoperative course, including intubation time and intensive care unit and hospital stays, were recorded.

Before surgical intervention, each patient underwent a bone scan with single photon emission computed tomography to evaluate the baseline sternal vascularity. A single-head gamma camera (Apex SP-4; Elscint, Ltd) equipped with a low-energy, high-resolution collimator (APC-45) was used. Imaging began 3 hours after intravenous injection of 740 MBq (20 mCi) of technetium-99m methylene diphosphonate (Soreq Pharmaceutical Co). Sixty projections of 20 seconds each, over a 180° anterior arc, were acquired from the right lateral position to the left lateral position in a 64 × 64 matrix at 3° angular steps. Transaxial, coronal, and sagittal slices 2 pixels thick were reconstructed with a third-order Metz filter set to 10 mm of FWHM. Only the coronal sections were used for quantitative analysis. A repeat bone single photon emission computed tomography was performed 4 to 10 (6 ± 2.4) days after surgical intervention by using the same parameters of camera distance and bed height for each patient.

The patients were then returned for a third scan 15 to 24 (18.6 ± 3.5) months after surgical intervention. At the time of the last scan, clinical follow-up was performed as well, which included number of readmissions, evidence of deep or superficial sternal infection, evidence of sternal instability, and sternal pain.

For quantitative analysis, the coronal image in which the sternum showed the greatest activity was selected and a region of interest drawn on the left half of the sternum. A similar region of interest was drawn on the right side of the sternum. The mean counts per pixel on the left side of the sternum compared with the right side was obtained for all patients before and after surgical intervention, and a left/right activity ratio was calculated.

Data are presented as means ± SD for continuous variables and as numbers of occurrences for noncontinuous variables. Cases

Figure 1. Left/right activity ratio derived from bone scan performed before the operation (*Preop*), days after the operation (*Postop*), and at follow-up (*Late*).

were compared by analysis of variance with post hoc pairwise comparisons by means of the Bonferroni method. Categorical variables were tested with the χ^2 test. Statistical analysis was performed with the aid of SPSS for Windows, release 8, statistical package (SPSS, Inc, Chicago, Ill).

Results

The study included 12 male patients with a mean age of 67 ± 8.7 years. Four patients had diabetes, and 2 had chronic obstructive pulmonary disease. Preoperative mean blood creatinine was 1.2 ± 0.25 mg/dL, and mean ejection fraction was 53% ± 12%. The mean cardiopulmonary bypass time was 115 ± 36 minutes, and the mean crossclamp time was 70 ± 20 minutes. There were no early deaths or major complications. Mean intensive care unit time was 54 ± 33.6 hours, and mean hospital time was 7.1 ± 2.9 days.

One patient died of cardiac disease during follow-up and was excluded from the study. The remaining patients all completed the 3 scans and clinical follow-up. The results of the scans are shown in Figure 1. In the immediate postoperative scans all patients showed evidence of reduction of flow to the left hemisternum compared with the preoperative scan ($P < .001$). The reductions ranged between 15% and 35%. In the late follow-up scans, the flow to the left hemisternum had returned to normal or showed evidence of hypervascularity ($P = .119$). Representative scans demonstrating the above findings are presented in Figure 2.

Three patients had superficial wound infection. Of those 3 patients, only 1 had diabetes. Figure 3 shows sternal vascularity measured with left/right hemisternal activity ratios for patients who had diabetes and for those who had superficial wound infection. There was no difference in sternal

Figure 2. Representative bone scans from 1 patient demonstrating normal preoperative sternal vascularity (A), decreased left hemisternal vascularity a week after the operation (arrow, B), and regained sternal vascularity 1 year after surgical intervention (C).

Figure 3. Left/right activity ratio derived from bone scan for patients with diabetes and for those who had superficial wound infection. *Preop*, Bone scan performed before the operation; *Postop*, bone scan performed after the operation; *Late*, bone scan performed at follow-up.

vascularity between either of these groups in any one of the measured periods ($P > .1$).

Midterm clinical follow-up is shown in Table 1. Five patients were readmitted to the hospital. The 3 patients who had superficial wound infection had it during the first 3 postoperative months. Ten patients had musculoskeletal pain at 3 months follow-up, which resolved in all patients at late follow-up. Three patients had numbness or tingling at the skin area, corresponding to the LITA harvesting site in late follow-up.

Discussion

Sternal complications after CABG continue to be a significant problem. Whether LITA harvest contributes to this problem is controversial. However, it is clear, by means of experimental and clinical evidence, that the harvest of a pedicled LITA causes sternal ischemia in the ipsilateral hemisternum.⁵ Whether the ischemia is temporary or long lasting is unknown. Bone healing starts immediately after fracture, with inflammatory response followed by bone formation and remodeling. This process is greatly dependent on adequate blood supply to the injured bone. When blood supply to the bone is disrupted, the fracture can still heal, but the rate and incidence of healing is reduced.⁶

Arnold² found the human sternum to be perfused solely from its periosteal plexus fed by predominantly segmental sternal branches of the ITAs. Thus, elimination of the ITA as a blood supply to a split sternum will likely delay healing, as well as revascularization.

Scant laboratory evidence has suggested that after harvest of an ipsilateral ITA, the ischemic hemisternum would regain its vascularity with time.⁴ This is most probably caused by ipsilateral collaterals from intercostal arteries and crossover circulation from the contralateral hemisternum. In this clinical study we have shown that an ischemic hemisternum after pedicled LITA harvest regains its vascularity over time. The fact that the sternum regains its vascularity is useful information should a patient be injured in that area late after CABG, in the treatment management of late fistula in this region, and in reoperations when harvesting the right ITA is considered.

The major limitation of this study is the time interval between the 2 last scans. We have shown that by 18.6 ± 3.5 months after surgical intervention, the sternum revascularizes. However, we have little information on the time frame in which the sternum regains its vascularity.

We conclude that sternal ischemia after single pedicled LITA harvest is a temporary condition that resolves with time.

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