To Skeletonize the Internal Thoracic Artery or Not?  
Is That the Question?

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The internal thoracic artery (ITA) is the preferred conduit for surgical coronary artery revascularization because of superior long-term patency rates and observational evidence of improved long-term outcomes. It is usually harvested with a pedicle of surrounding tissue, presumably not to disrupt its viability and blood supply. Resultant hypoperfusion of the sternum and an increased rate of sternal wound infections, particularly when bilateral ITAs are used, have prompted certain surgeons to harvest the ITA in a skeletonized fashion, ie, without its surrounding tissue. Stripping the ITA from its surrounding tissues interrupts its nerve and blood supply and may hypothetically interfere with its function and reactivity. However, studies that have addressed this issue, including 2 randomized studies by Gaudino and his group,1,2 have provided convincing evidence that the integrity and reactivity of the skeletonized and pedicled ITA are similar.

1. Does skeletonization of the ITA improve sternal hypoperfusion compared with pedicle harvesting of the ITA? The study used standard nuclear imaging to evaluate sternal vascularity. It demonstrated a 17% increase in sternal perfusion on the side of the skeletonized artery compared with the side of the pedicled artery. Several previously published studies had provided good evidence of decreased sternal perfusion after ITA harvesting.3,4 Through its intrapatient design, this study confirmed a previous randomized study involving the left ITA5 and provided additional class I evidence of the fact that harvesting the ITA in the skeletonized fashion results in less hypoperfusion of the sternum than harvesting the ITA as a pedicle.

2. Does skeletonization of the ITA decrease postoperative pain and reduce sensory deficits compared with pedicle harvesting? Similar to sternal perfusion, the randomized intrapatient design used in this study provided convincing evidence that postoperative anterior chest pain and dysesthesia at 3 months after surgery were markedly reduced on the side of the skeletonized ITA compared with the side of the pedicled ITA. The intrapatient design was particularly appropriate for the assessment of pain and sensory deficits because it eliminated the wide variation between patients in areas such as their tolerance for pain and use of analgesics and other related medications. Only one previous study prospectively randomized patients to skeletonized versus pedicle harvesting of the left ITA; it was not as definitive with regard to early postoperative pain, but it did demonstrate, 3 months postoperatively, a similar reduction in a multidimensional pain score in patients subjected to skeletonized harvesting of the ITA.6

3. Does skeletonization improve ITA blood flow and conduit length compared with pedicle harvesting? The study by Boodhwani et al7 provided the best evidence yet that skeletonization does not increase ITA blood flow compared with conventional pedicle harvesting. This is important because the compendium of published studies to date1 have been contradictory to this finding and have shown an increase in ITA blood flow in patients undergoing skeletonized harvesting compared with patients undergoing pedicle harvesting. Athanasiou et al8 conducted a meta-analysis of 4 studies comparing the free flow in the ITA, harvested as a pedicled or skeletonized conduit. It showed that the weighted mean difference of the ITA flow was 32.88 mL/min in favor of the skeletonized conduit.

Should we believe the conclusions of Boodhwani et al with regard to the ITA blood flow over almost all of the previously published studies? Most of the published studies that compared flow in the skeletonized and pedicled ITA depended on measurement of free flow in the conduit. Free flow is measured after harvesting and dividing the ITA distally and then obtaining a direct timed measurement of the flow. Flow in the conduit, whether measured as free flow or in situ by a flowmeter, is dependent on a wide variety of patient-specific variables that are in play at the time of the measurement. These include, in part, systemic pressure, distal vascular resistance, pulsatility, anesthetic and other medications, and capacity for autoregulation. A randomized design...
to account for all of these confounding factors is imperative if a proper assessment of the effect of skeletonization on blood flow is sought. Except for 1, all previously published studies comparing flow in pedicled and skeletonized ITA were nonrandomized. The single randomized study,9 which was included in the meta-analysis by Athanasiou et al,3 was the only study in the analysis in which the difference between free flow in the skeletonized and pedicled conduits did not reach statistical significance, albeit the number of patients in that study was relatively small. The design of the Boodhwani study was superior to all previously conducted studies. Both free flow and in situ conduit flow were measured on 4 separate occasions. The use of an intrapatient comparison and randomization of the side and the order of harvesting the ITA eliminated the confounding effect of numerous patient variables that could potentially influence conduit flow. Until other equally well-conducted studies provide contrary evidence, it is prudent for the cardiac surgical community not to consider increased conduit flow as an indication for skeletonized harvesting of the ITA.

The Boodhwani study was not as definitive about the effect of skeletonizing the ITA on conduit length, although its design was most appropriate for such an investigation. A trend toward increased length in the skeletonized grafts was observed. The difference in length between the 2 types of harvested grafts did not reach statistical significance, probably because of the relatively small sample size of the study. The study, therefore, does not alter the insufficient evidence in the current literature with regard to the potential advantage of increased length in the skeletonized ITA.

The study by Boodhwani et al,4 primarily because of design limitations, leaves unanswered 3 important questions:

1. Does skeletonized harvesting of the ITA reduce superficial and deep sternal wound infections? The study provides compelling evidence and corroborates numerous other studies indicating that hypoperfusion of the sternum, and hence possible vulnerability to infection, is reduced by the skeletonization technique. To date, there have been no randomized studies addressing the role of skeletonization in the prevention of sternal wound infection. Our current knowledge in regard to this issue is based solely on observational studies.10,11 The compendium of these studies provides reasonable evidence that in the diabetic patient population, sternal wound infection rates after bilateral ITA harvesting are higher than after single-ITA harvesting. They also show that compared with pedicled bilateral harvesting of the ITA, bilateral skeletonized harvesting reduces sternal infection rates only in the diabetic patient population. Hence, current best evidence derived from these studies, and from the hypoperfusion data provided by the Boodhwani study,4 indicates that skeletonized harvesting of the ITA should be performed in diabetic patients undergoing bilateral ITA revascularization.

2. Is there a role for skeletonized harvesting of a single ITA? The study by Boodhwani et al4 was not adequately designed to answer whether skeletonization would reduce pain in single-ITA harvesting, and the literature evidence is insufficient in this regard.3 As discussed above, there is insufficient evidence that skeletonized harvesting of a single ITA reduces sternal wound infection, even in the diabetic patient population. The Boodhwani study provided new Class I evidence that skeletonization does not improve conduit flow, and insufficient evidence as to whether skeletonization increased conduit length. Therefore, based on the available of current evidence, the only justification left for skeletonized harvesting of a single ITA is maintenance of provider competence, should the provider need to perform bilateral ITA revascularization, which is indicated in the diabetic patient population. There is advantage in eliminating the adverse effects of a steep learning curve, and, to date, there is no evidence that skeletonization of ITA, when properly performed, is injurious to the patient.

3. Does bilateral skeletonized harvesting of the ITA improve outcomes other than sternal wound infection in the diabetic population? As reviewed by Athanasiou et al,3 there have been no prospective randomized trials comparing angiographic patency and long-term outcomes of skeletonized ITA versus pedicled ITA. Observational studies have also been inconsistent with regard to other outcomes such as pulmonary complications and have provided insufficient evidence as to whether skeletonization improves outcomes other than those discussed above.

The More Important Question

The new finding that skeletonized harvesting of the ITA does not improve conduit flow denies the surgeon the means to address a serious problem that is occasionally encountered in ITA revascularization and prompts the surgeon to explore new means with which this problem can be addressed. Occasionally, ITA flow may not be sufficient to meet the metabolic demands of the myocardial segments it subtends, leading to segmental hypoperfusion and inadequate revascularization and sometimes resulting in catastrophic perioperative events.12 ITA spasm may contribute to this hypoperfusion, but the predominant cause is an absolute low flow rate that is determined by the characteristics of the ITA. Proponents of skeletonization of the ITA had hoped to use this technique to augment ITA flow and prevent hypoperfusion. The study by Boodhwani et al10 has put a damper on this approach and now prompts us to seek other venues.

Is the ITA flow enough? The key to answering this important question is the ability to monitor the metabolic state of the heart while one is in the process of revascularizing it. Regional myocardial tissue pH, measured directly with a plume glass electrode, has been shown to be a sensitive indicator of regional myocardial perfusion13 and of the adequacy of myocardial revascularization.14 We have learned from more than 1400 patients in whom regional myocardial tissue pH was monitored intraoperatively that hypoperfusion and inadequate revascularization of the anterior wall (evidenced by persistent myocardial acidosis) are not infrequent after revascularization with the ITA. In a study of 496 patients who were followed up for an average of 10 years, myocardial tissue acidosis (pH <6.73) at the end of cardiopulmonary bypass, in either the anterior or the posterior LV wall, was independently determinant of a 25.5% decrease in median long-term survival after cardiac surgery (Figure).15 Failure of the skeletonized harvesting of the ITA to improve conduit flow and the reduction in long-term patient survival secondary to inadequate revascularization should continue prompting cardiac surgeons to address the more important
question, “Is the ITA flow enough? How can I tell? If ITA flow is not enough, how can I improve it?”

Conclusions
The combination of current evidence in the literature and new evidence provided by Boodhwani et al indicates that skeletonized harvesting of the ITA reduces pain and hypoperfusion of the sternum compared with conventional pedicle harvesting. This combined evidence confirms that skeletonized harvesting of the ITA should be indicated in diabetic patients undergoing bilateral ITA revascularization. Contrary to previous assumptions, skeletonized harvesting of the ITA does not result in increased conduit flow compared with pedicle harvesting. The comparability of conduit flow between the 2 harvesting modes rules out skeletonization of the ITA as a means to correct the mismatch that might occur between ITA flow and metabolic demands. Intraoperative monitoring of regional myocardial acidosis is an alternative approach that can identify limited ITA flow and prompt additional revascularization to improve patient outcomes.

Disclosures
Dr Khuri is a consultant to Terumo Cardiovascular Systems Corporation and E-Monitors, Inc.

References
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