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Determinants of Successful Endoscopic Internal Thoracic Artery Harvesting: A Prospective Analysis

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ABSTRACT

Objective: Endoscopic internal thoracic artery (ITA) harvesting is employed during minimal-access coronary artery bypass grafting. To improve case selection, we prospectively analyzed our entire experience to identify variables that predict intraoperative conversion to sternotomy.

Methods: We performed a prospective study from September 1999 to November 2003 of 100 consecutive patients with an endoscopically harvested left ITA (LITA). Success was defined as an endoscopic dissection of the LITA sufficient to reach the anastomosis. Multivariate logistic regression analysis was performed to identify independent preoperative and procedural predictors of success.

Results: The measured parameters (mean ± SD) were age (62 ± 9 years), height (174 ± 9 cm), weight (81 ± 14 kg), and logistic Euroscore (2.0 ± 1.7). Patients comprised 8 (8%) women, 17 (17%) with urgent operations, 42 (42%) with multiple vessel disease, 17 (17%) with a left ventricular ejection fraction <50%, 2 (2%) redo procedures, and 3 (3%) with pleural disease. The Zeus robot was used in 17 patients (17%). Eight-eight (88%) of the LITA were successfully harvested endoscopically. Among the 12 patients who underwent conversions, pleural adhesions were the most common finding (n = 4, 33%). One LITA was unusable. In the final multivariate model, lung disease was a negative predictor of successful endoscopic harvest (odds ratio, 0.13; 95% confidence interval, 0.02-0.63; $P = .012$). The variables of age, sex, left ventricular function, logistic Euroscore, operative priority, and use of the Zeus robot did not achieve statistical significance.

Conclusions: Acceptable conversion rates and low conduit wastage are achievable during a unit's initial experience. Lung disease is associated with increased conversion frequency, and surgeons embarking on endoscopic harvesting should consider excluding these patients to improve their chances of success. Pleural adhesions increase the technical difficulty of surgery.

INTRODUCTION

Endoscopic internal thoracic artery (ITA) harvest is an essential component of minimally invasive coronary artery bypass graft (CABG) operations, including totally endoscopic CABG (TECAB) and the endoscopic atraumatic coronary artery bypass (endo-ACAB) procedure [Vassiliades 2001]. Advantages of an endoscopic approach include less early postoperative pain compared with both the median sternotomy and minimally invasive direct coronary artery bypass (MIDCAB) approaches [Bucerius 2002] and enhanced exposure of the proximal ITA [Duhaylongsod 1998]. Robotic surgical devices have also been used to perform endoscopic ITA harvest [Loulmet 1999]. The ability of these devices to provide fine manipulation, improved ergonomics, and the damping of physiological tremor may have benefits.

It is important to define appropriate patient selection criteria for endoscopic harvest and to describe the common intraoperative pitfalls as more units seek to adopt the technique. Not all patients are suitable for endoscopic surgery, and several patient factors have been associated with technical difficulty, including abundant pericardial fat [Duhaylongsod 1998], obesity, female sex, and pleurodesis [Nataf 2000, Vassiliades 2002]. Although successful series of redo patients have been reported, the technical challenge of these patients is greater [Wolf 1999].

Unsuccessful endoscopic harvest involves unnecessary single-lung ventilation, double-lumen endotracheal intubation (or left bronchial obstruction), unnecessary endoscopic incisions, and increased operating theater time. Good case selection allows patients unsuitable for endoscopic harvest to avoid these problems, saving the endoscopic approach for those likely to benefit.

We performed a prospective study of our entire experience with endoscopic harvesting of the left ITA, from the first clinical cases in our institution. We analyzed these data to identify preoperative variables associated with the intraoperative conversion from endoscopic to open harvest. By identifying these variables, we intend to refine patient selection for endoscopic techniques such as endo-ACAB and TECAB. In addition, we describe the operative findings for those patients in whom we were unable to perform an endoscopic harvest.

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METHODS

We have developed a minimally invasive and robotic CABG program at our institution that has been in use since 1999. During this time, we performed endoscopic ITA harvest as a prelude to open CABG, endo-ACAB, and TECAB procedures. We collected patient data preoperatively and prospectively recorded the need for conversion to sternotomy and the intraoperative reason for conversion.

Case Selection

Patients underwent endoscopic ITA harvest in 3 situations: First, prior to a planned sternotomy CABG; second, as a prelude to endo-ACAB or TECAB procedures for single-vessel coronary artery disease; and last, as part of the endo-ACAB component of a hybrid surgical and percutaneous strategy for multivessel disease. Emergency surgery and severely impaired lung function precluding single lung ventilation were considered absolute contraindications to endoscopic harvest. Previous cardiac or left chest surgery, obesity (body mass index >35) or significant chest wall adipose tissue, a history of pleural disease, and left shoulder immobility were considered relative contraindications.

Surgical Technique

The technique of endoscopic ITA harvest with the Harmonic Scalpel (Ethicon Endo-Surgery, Cincinnati, OH, USA) has been described by other authors [Ohtsuka 1997, Wolf 1998]. Briefly, a double-lumen endotracheal tube (BronchoCath [Mallinckrodt Medical, Athlone, Ireland] or Robertshaw double-lumen endobronchial tube [Phoenix Medical, Glenrothes, UK]) or a left bronchial blocker was used to allow isolation of the left lung. Tube position was confirmed with a fiber-optic bronchoscope. After isolating the left lung from the ventilator, we insufflated carbon dioxide into the left pleural space at a pressure of 4 to 8 mm Hg by means of a pressure-regulated high-flow insufflator (Stryker, Newbury, UK) and 3 thoracoscope ports introduced between the anterior and midaxillary lines.

In approximately the fifth intercostal space, a 30° Storz 2D camera 5 mm in diameter with insufflation port (Karl Storz, Tuttlingen, Germany) was inserted with a Harmonic Scalpel superiorly and a blunt dissection probe inferiorly. An 8F catheter Veress needle was inserted medially in the fifth intercostal space to vent airborne dissection debris. The ITA was dissected proximally to distally, beginning at the level of the subclavian vein. In robotically assisted cases, the Zeus telemanipulator system (Computer Motion, Goleta, CA, USA) was used to control the Harmonic Scalpel and the dissection probe; the procedure was identical in all other aspects.

In all cases, the ITA was harvested via a totally endoscopic approach without open assistance of any kind. When endoscopic harvest proved impossible, sternotomy was performed for conversion to open harvesting. Success was defined as a dissection of the ITA sufficient to reach the planned anastomosis site without any dissection via an open approach (ie, a totally endoscopic dissection). In all cases, the planned anastomotic site was within the left anterior descending or circumflex coronary arterial systems. If further dissection was necessary via sternotomy, the ITA harvest was counted as a failed endoscopic dissection. MIDCAB or thoracotomy approaches were not used. All operations in this series were performed in the same center by 1 of 3 surgeons (A.D.S., J.P., and J.Y.).

Data Collection

The data collected for analysis were for the following 14 variables: age, weight, height, sex, left ventricular function, presence of multiple-vessel coronary artery disease, operative priority, logistic Euroscore, Canadian Cardiovascular Society score, New York Heart Association score, presence of pleural disease, presence of chronic obstructive airway disease or asthma, previous surgery, and use of the Zeus robot to control the instruments.

Preoperative data, operative variables, and the success of endoscopic dissection were recorded prospectively. In cases of conversion, the reason for conversion as described by the operating surgeon was recorded.

Left ventricular function estimation was made from the preoperative ventriculogram, and patients were grouped into 3 ejection fraction categories: good (>49%), moderate (30%-49%), or poor (<30%). Chronic obstructive pulmonary disease and asthma were defined as the presence of pulmonary disease requiring regular treatment with inhaled or systemic medication. Pleural disease was defined as a diagnosis of inflammatory pleural disease or known pleurodesis at any time prior to surgery. Previous or current pleural effusions were not recorded as pleural disease for the purpose of this study.

Statistical Analysis

Baseline characteristics are presented as the mean ± SD. Patients were grouped according to success of endoscopic ITA harvesting, and dichotomous outcomes were compared by means of the chi-square test or the Fisher exact text. Continuous variables were compared using the 2-tailed *t* test. The data for 14 exploratory variables that could potentially affect the success of endoscopic ITA harvesting were entered into a logistic regression analysis. Predictors of success were then entered into a forward and backward stepwise multivariate model, with the criterion for variable retention set at a significance level of .05. Statistical analysis was performed with S-Plus 6.0 (Insightful Corporation, Seattle, WA, USA) and Stata 8.2 (StataCorp, College Station, TX, USA) software packages.

RESULTS

From September 1999 to November 2003, 100 endoscopic ITA dissections were attempted. The sample means for age, body mass index, height, and weight were 62 ± 9 years, 26.9 ± 4.1, 174 ± 9.3 cm, and 81 ± 14.0 kg, respectively. There were 8 (8%) female patients, 42 patients (42%) with multiple-vessel disease, 16 (16%) urgent operations, and 17 patients (17%) with an ejection fraction <50%. The Zeus robotic system was used in 17 patients (17%). Eighty-eight (88%) of the endoscopic dissections were completed successfully, and 12 dissec-

Table 1. Summary of Patients Converted to Open Internal Thoracic Artery (ITA) Harvesting*

Case	Sex	Zeus	BMI	PMH	Stated Reason for Conversion
1	M	No	30.6	Nil	Poor access; operating port obstructed
2	M	No	24.9	Pleural disease	Pleural adhesions prevented dissection
3	F	No	28.3	Nil	Pleural adhesions prevented dissection
4	M	Yes	28.4	Nil	Bleeding from mid ITA
5	M	No	21.5	Nil	ITA damaged during dissection, unusable
6	M	No	28.6	Previous VSD repair	Pleural adhesions prevented dissection
7	M	No	40.3	Nil	ITA obscured by fat
8	F	No	23.5	Pulmonary disease	Unable to pass double-lumen endotracheal tube
9	M	Yes	20.7	Nil	ITA damaged during dissection; length resected via sternotomy; ITA used
10	M	No	32.5	Nil	ITA obscured by fat
11	M	No	30.4	Pulmonary disease	Poor access; operating port obstructed
12	M	No	31.9	Pleural disease	Pleural adhesions prevented dissection

*BMI indicates body mass index; PMH, previous medical history; pleural disease, a history of previous inflammatory pleural disease or pleural adhesions; ITA, internal thoracic artery; VSD, ventricular septal defect; pulmonary disease, history of chronic obstructive pulmonary disease or asthma requiring regular inhaled medication.

tions (12%) were converted to sternotomy to complete the ITA harvest (Table 1). The comparative baseline characteristics are summarized in Table 2. Significant differences between successful and converted groups existed for patient height and the presence of lung and pleural disease.

Of the 100 patients, the ITA was unusable in 1 case (1%). There was a trend toward a lower conversion rate in the second 50 cases compared with the first 50 cases (8% versus 16%; $P = .16$).

The univariate predictors of outcome are summarized in Table 3. In the final multivariate model, lung disease was an independent predictor of failure of endoscopic ITA harvesting (odds ratio of success, 0.10; 95% confidence interval, 0.02-0.51; $P = .006$). Increasing height did not achieve significance (odds ratio of success, 1.06/cm; 95% confidence interval, 0.99-1.14; $P = .07$).

DISCUSSION

Our overall conversion rate (12%) was similar to that (8%) of a previously published series [Duhaylongsod 1998]. The present study includes our entire experience, from the initial phase of our learning curve to the present day. With refined case selection and increasing experience, lower conversion rates may well be possible in the future.

We preferentially chose elective cases without previous surgery. Pleural disease was considered a relative contraindication. As a result, only 2 cases of redo surgery (1 ventricular septal defect repair and 1 all–saphenous vein CABG) and 3 cases of known pleural disease were included. We designed this strategy to increase our success rate, but it reduced the power of the study to detect the effects of these variables. Larger series are needed to ascertain the precise effect of pleural disease and postoperative scarring on success rates.

The most common intraoperative finding in the patients who underwent conversion was pleural adhesions (4 patients, 33%). Only 2 (50%) of these patients gave a preoperative history of pleural disease. Pleural adhesions are often asymptomatic, making it difficult to exclude all patients with pleural disease from clinical history alone. Further preoperative investigation, including the use of chest computed tomography scanning, may improve the preoperative diagnosis of pleurodesis. Poor access from the chosen port sites was responsible for 2 conversions. In both cases,

Table 2. Baseline Characteristics*

	Successful Endoscopic Harvest (n = 88)	Conversion to Sternotomy (n = 12)	P
Age, y	62 ± 9	60 ± 11	.42
Male sex, n (%)	82 (93)	10 (83)	.25
Body mass index	26.7 ± 3.9	28.4 ± 5.4	.17
Height, cm	174 ± 9	168 ± 13	.03
Weight, kg	81 ± 13	82 ± 23	.90
Lung disease, n (%)	5 (6)	4 (33)	.001
Pleural disease, n (%)	1 (1)	2 (17)	.04
Revision procedure, n (%)	1 (1)	1 (8)	.23
Multivessel disease, n (%)	36 (41)	6 (50)	.82
Preoperative status			
CCS I/II, n (%)	60 (68)	8 (67)	
CCS III/IV, n (%)	28 (32)	4 (33)	.91
NYHA I/II, n (%)	74 (84)	10 (83)	
NYHA III/IV, n (%)	14 (16)	2 (17)	.95
Logistic Euroscore	2.0 ± 1.7	1.7 ± 0.9	.52
Operative urgency			
Elective, n (%)	72 (82)	11 (92)	
Urgent, n (%)	15 (17)	1 (8)	
Emergency, n (%)	0 (0)	0 (0)	.68
Left ventricular ejection fraction			
Good (>50%), n (%)	73 (83)	10 (83)	
Moderate (30%-49%), n (%)	13 (15)	2 (17)	
Poor (<30%), n (%)	2 (2)	0 (0)	.86
Zeus used, n (%)	15 (17)	2 (17)	.97

*Data are presented as the mean ± SD where appropriate. CCS indicates Canadian Cardiovascular Society; NYHA, New York Heart Association.

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Table 3. Univariate Predictors of Successful Endoscopic Harvesting*

	Odds Ratio (95% CI)	*P*
Left ventricular function†	0.12 (0.12-1.58)	.11
Age per y	0.93 (0.80-1.09)	.39
Lung disease	0.01 (<0.00-0.39)	.02
Multivessel disease	0.39 (0.61-2.51)	.32
Height per cm	1.14 (0.99-1.31)	.07
Weight per kg	0.95 (0.89-1.02)	.17
Zeus	0.67 (0.76-5.84)	.71
Pleural disease	0.01 (<0.00-4.10)	.14

*Results from the variables of sex, operative urgency, logistic Euroscore, Canadian Cardiovascular Society and New York Heart Association functional scores, and previous surgery were not reported because of the instability of the estimates from the small numbers of extreme values in each group. CI indicates confidence interval.

†Normal ventricular function compared with impaired function (<50% ejection fraction).

poor mobility at the superior (Harmonic Scalpel) port site was responsible. Our routine practice now is to move the Harmonic Scalpel port down 1 intercostal space (via the same skin incision) when dissection of the distal ITA is being hampered.

The effect of chronic lung disease as a predictor of conversion is interesting. It is possible that suboptimal deflation of the lung due to air trapping, pleural adhesions associated with previous infective exacerbations, or changes in the shape of the thorax following chronic hyperinflation may increase the technical difficulty of operating in these patients. At present, the exact mechanism is unclear. Conversely, minimal-access surgery may improve postoperative respiratory function compared with that after sternotomy [Lichtenberg 2000]. Surgeons should be aware of the higher risk of conversion for patients with lung disease, but an endoscopic approach may still be appropriate given the potential postoperative benefits. The use of the Zeus robot did not affect the risk of conversion and was an acceptable alternative in this series to a conventional endoscopic approach.

The trend toward increasing height as a predictor of success did not reach significance in the final multivariate model. Larger internal thoracic vessels and greater intrathoracic volume may aid dissection. As our series grows, the effect of height on success will become clearer.

It is encouraging that age, impaired left ventricular function, logistic Euroscore, and multiple-vessel disease were not significantly associated with failure, because high-risk patients may have most to gain from minimal-access procedures in terms of faster recovery. However, we are aware of the small number of high-risk patients in our series, hence our caution in the interpretation of these findings. Although our clinical impression was that obese and female patients were technically more challenging, neither body mass index nor sex showed a correlation with conversion in this series.

Our end point for this study was the success of the harvesting procedure, and no conclusions on the effect of endoscopic harvest on the postoperative course can be drawn.

CONCLUSION

Careful case selection is essential for optimal results. The data from our study suggest that low conversion rates are possible early in a surgical unit's experience. The introduction of an endoscopic ITA program is compatible with a very low level of conduit wastage. Chronic obstructive airway disease and asthma increase the risk of conversion, and surgeons embarking on endoscopic ITA harvest should avoid these patients if they wish to reduce unnecessary conversions in their early experience with the procedure. Pleural adhesions increase the technical difficulty of endoscopic harvest. Variables associated with increased operative risk, including impaired left ventricular function and the logistic Euroscore, did not have an impact on the success of the endoscopic approach in this series.

REFERENCES

Bucerius J, Metz S, Walther T, et al. 2002. Endoscopic internal thoracic artery dissection leads to significant reduction of pain after minimally invasive direct coronary artery bypass graft surgery. Ann Thorac Surg 73:1180-4.

Duhaylongsod FG, Mayfield WR, Wolf RK. 1998. Endoscopic harvest of the internal thoracic artery: a multicenter experience in 218 cases. Ann Thorac Surg 66:1012-7.

Lichtenberg A, Hagl C, Harringer W, Klima U, Haverich A. 2000. Effects of minimal invasive coronary artery bypass on pulmonary function and postoperative pain. Ann Thorac Surg 70:461-5.

Loulmet D, Carpentier A, d'Attellis N, et al. 1999. Endoscopic coronary artery bypass grafting with the aid of robotic assisted instruments. J Thorac Cardiovasc Surg 118:4-10.

Nataf P, Al-Attar N, Ramadan R, et al. 2000. Thoracoscopic IMA takedown. J Card Surg 15:278-82.

Ohtsuka T, Wolf RK, Hiratzka LF, et al. 1997. Thoracoscopic internal mammary artery harvest for MICABG using the Harmonic Scalpel. Ann Thorac Surg 63(suppl):S107-9.

Vasilliades TA Jr. 2001. Atraumatic coronary artery bypass (ACAB): techniques and outcome. Heart Surg Forum 4:331-4.

Vassiliades TA Jr. 2002. Technical aids to performing thoracoscopic robotically-assisted internal mammary artery harvesting. Heart Surg Forum 5:119-24.

Wolf RK, Miyaji K, Flege JB Jr. 1999. Thoracoscopic mammary artery mobilization in redo minimally invasive coronary bypass operations. Ann Thorac Surg 68:1540-1.

Wolf RK, Ohtsuka T, Flege JB Jr. 1998. Early results of thoracoscopic internal mammary artery harvest using an ultrasonic scalpel. Eur J Cardiothorac Surg 14:S54-7.