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Anatomic pulmonary resection by video-assisted thoracoscopy: the Brazilian experience (VATS Brazil study)

Ricardo Mingarini Terra[1], Thamara Kazantzis[1], Darcy Ribeiro Pinto-Filho[2], Spencer Marcantonio Camargo[3], Francisco Martins-Neto[4,5], Anderson Nassar Guimarães[6], Carlos Alberto Araújo[7], Luis Carlos Losso[8], Mario Claudio Ghefter[9], Nuno Ferreira de Lima[10], Antero Gomes-Neto[5], Flávio Brito-Filho[10], Rui Haddad[11], Maurício Guidi Saueressig[12], Alexandre Marcelo Rodrigues Lima[13], Rafael Pontes de Siqueira[5], Astunaldo Júnior de Macedo e Pinho[14], Fernando Vannucci[15]

1. Departamento de Cardiopneumologia, Disciplina de Cirurgia Torácica, Instituto do Coração, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, São Paulo (SP) Brasil.
2. Serviço de Cirurgia Torácica, Hospital Geral de Caxias do Sul, Fundação Universidade de Caxias do Sul (RS) Brasil.
3. Serviço de Cirurgia Torácica, Pavilhão Pereira Filho, Complexo Hospitalar da Santa Casa de Porto Alegre, Porto Alegre (RS) Brasil.
4. Hospital Monte Klinikum, Fortaleza (CE) Brasil.
5. Hospital de Messejana Doutor Carlos Alberto Studart Gomes, Fortaleza (CE) Brasil.
6. Casa de Saúde São José, Rio de Janeiro (RJ) Brasil.
7. Universidade Federal do Rio Grande do Norte, Natal (RN) Brasil.
8. Hospital Professor Edmundo Vasconcelos, São Paulo (SP) Brasil.
9. Hospital do Servidor Público Estadual de São Paulo, São Paulo (SP) Brasil.
10. Hospital de Base do Distrito Federal, Brasília (DF) Brasil.
11. Hospital Samaritano, Rio de Janeiro (RJ) Brasil.
12. Serviço de Cirurgia Torácica, Hospital de Clínicas de Porto Alegre, Faculdade de Medicina, Universidade Federal do Rio Grande do Sul, Porto Alegre (RS) Brasil.
13. Hospital Geral César Cals, Fortaleza (CE) Brasil.
14. Instituto Mário Penna, Hospital Luxemburgo, Belo Horizonte (MG) Brasil.
15. Hospital Naval Marcílio Dias, Rio de Janeiro (RJ) Brasil.

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ABSTRACT

Objective: The objective of this study was to describe the results of anatomic pulmonary resections performed by video-assisted thoracoscopy in Brazil. **Methods:** Thoracic surgeons (members of the Brazilian Society of Thoracic Surgery) were invited, via e-mail, to participate in the study. Eighteen surgeons participated in the project by providing us with retrospective databases containing information related to anatomic pulmonary resections performed by video-assisted thoracoscopy. Demographic, surgical, and postoperative data were collected with a standardized instrument, after which they were compiled and analyzed. **Results:** The surgeons provided data related to a collective total of 786 patients (mean number of resections per surgeon, 43.6). However, 137 patients were excluded because some data were missing. Therefore, the study sample comprised 649 patients. The mean age of the patients was 61.7 years. Of the 649 patients, 295 (45.5%) were male. The majority—521 (89.8%)—had undergone surgery for neoplasia, which was most often classified as stage IA. The median duration of pleural drainage was 3 days, and the median hospital stay was 4 days. Of the 649 procedures evaluated, 598 (91.2%) were lobectomies. Conversion to thoracotomy was necessary in 30 cases (4.6%). Postoperative complications occurred in 124 patients (19.1%), the most common complications being pneumonia, prolonged air leaks, and atelectasis. The 30-day mortality rate was 2.0%, advanced age and diabetes being found to be predictors of mortality. **Conclusions:** Our analysis of this representative sample of patients undergoing pulmonary resection by video-assisted thoracoscopy in Brazil showed that the procedure is practicable and safe, as well as being comparable to those performed in other countries.

Keywords: Thoracic surgery, video-assisted; Thoracoscopy; Pneumonectomy.

INTRODUCTION

In the last 20 years, the development of minimally invasive surgery has evolved constantly. This technique minimizes trauma response and optimizes patient recovery without compromising surgical results.[1-5] Thoracic surgery has followed this same path, which means that anatomic pulmonary resections by video-assisted thoracoscopy are routinely performed in hospitals around the world, and the number of studies that report increasingly complex surgeries, such as video-assisted thoracoscopic lobectomy with bronchoplasty for the treatment of hilar lymph node enlargement and large tumors, has increased in recent years.[6-11]

Despite the proven advantages of the minimally invasive approach, technical and financial limitations make its implementation difficult, especially in developing countries, such as India, Mexico, and Brazil. Therefore, to date, we do not yet have data from studies conducted in Brazil that can confirm the applicability and safety of the technique in our country, taking into account the particular characteristics of the patients and centers that provide care to them.[1,2,4,12]

The primary objective of the present study was to analyze the results of anatomic pulmonary resections performed by video-assisted thoracoscopy in Brazil, including

Correspondence to:
Ricardo Mingarini Terra. Avenida Dr. Enéas de Carvalho Aguiar, 44, Bloco II, 2º Andar, Sala 9, CEP 05403-900, São Paulo, SP, Brasil.
Tel.: 55 11 2661-5000. E-mail: rmterra@uol.com.br
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intraoperative complications, postoperative complications, and 30-day mortality. As a secondary objective, we sought to determine predictors of postoperative complications and 30-day mortality in our current scenario.

METHODS

This was a retrospective study commissioned by the *Sociedade Brasileira de Cirurgia Torácica* (SBCT, Brazilian Society of Thoracic Surgery), including data provided by 14 thoracic surgery groups in Brazil. The participating groups volunteered to donate data to the present study after an invitation was sent via e-mail to all members of the SBCT. To participate, interested parties should provide data related to anatomic pulmonary resections performed by video-assisted thoracoscopy. The minimum number of cases required for a group to be eligible for participation was 20 complete cases. The study project was approved by the Research Ethics Committee of the University of São Paulo School of Medicine (CAAE no. 40434414.6.0000.0065).

Cases of patients who underwent anatomic pulmonary resection by video-assisted thoracoscopy were included. Anatomic resections are those in which dissection and ligation is carried out regardless of the hilar structures, consisting of segmentectomy, lobectomy, or pneumonectomy. Video-assisted thoracoscopic procedures were defined as those in which there was no intercostal separation and incisions were < 8 cm.[13] Cases in which data on preoperative comorbidities, length of hospital stay, and postoperative complications were missing were excluded. The absence of only one of these data sets was not considered to be an exclusion criterion.

After accepting the invitation from the SBCT, the interested parties contacted the corresponding author and received a standardized instrument for data collection. The instrument contained closed-ended response fields and definitions for each variable.

The variables collected consisted of patient demographics (age, gender, diagnosis, and comorbidities), surgery-related data (date, type of procedure, and intraoperative complications), and surgical results (duration of drainage, length of hospital stay, and morbidity). Below are the definitions used for the various postoperative variables collected[14-17]:

Respiratory complications

- Pneumonia: presence of persistent or progressive pulmonary infiltrates on chest X-ray and at least two of the following clinical criteria: temperature ≥ 38°C; leukocytosis > 12,000 cells/μL or leukopenia < 3,000 cells/μL; or purulent tracheal secretions with ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per field (magnification, ×100)
- Pulmonary thromboembolism diagnosed by CT angiography
- Atelectasis requiring bronchoscopic intervention
- Respiratory failure: prolonged intubation (> 48 h or need for orotracheal reintubation in the postoperative period)
- ARDS: hypoxemia and diffuse pulmonary infiltrates with a PaO_2/FiO_2 < 200

Cardiac complications

- Acute myocardial infarction within 14 days after surgery: as determined on the basis of creatine phosphokinase > 30 ng/mL (5 times above normal), troponin I > 5 ng/mL within 72 h after surgery, the presence of new pathological Q waves, or the medical record entry
- Arrhythmia requiring intervention or delaying hospital discharge

Infectious complications

- Sepsis: suspected infection associated with at least two of the following variables[18-20]:
  - Temperature > 38°C or < 36°C
  - Heart rate > 90 bpm
  - Respiratory rate > 20 breaths/min
  - Blood workup showing leukocytosis (>12,000 cells/μL), leukopenia (< 4,000 cells/μL), or more than 10% of immature forms
  - Signs of organ dysfunction, such as systolic blood pressure < 90 mmHg, mean arterial pressure < 70 mmHg, PaO_2/FiO_2 < 300, diuresis < 0.5 mL/kg/h, creatinine elevation > 0.5 mg/dL, international normalized ratio > 1.5 or prothrombin time > 60 s, platelets < 100,000/μL, or plasma total bilirubin > 4 mg/dL
  - Pleural empyema
  - Surgical wound infection

Renal and metabolic complications

- Kidney injury: creatinine >1.5 mg/dL or creatinine elevation > 0.5 mg/dL within 24 h

Hematological complications

- Deep vein thrombosis (confirmed by Doppler)

Neurological complications

- Stroke
- Delirium

Surgical complications

- Need for blood transfusion
- Prolonged drainage (longer than 7 days)
- Prolonged air leaks (longer than 7 days)
- Inadvertent injury to intrathoracic structures
- Bronchial stump fistula
- Reoperation

Other definitions

Readmission within 60 days and 30-day mortality, regardless of their cause

All complications were recorded individually; however, the number of patients/cases with complications is what was used for analysis, given that various patients had more than one complication.

In the present study, categorical variables are expressed as absolute numbers and proportions. All numerical variables were tested for normality of distribution with the use of graphical methods and the Shapiro-Wilk test. Variables with normal distribution are expressed as means and standard deviations; those with non-normal distribution are expressed as medians and interquartile ranges (25-75%). To determine predictors of 30-day mortality and postoperative complications, we used logistic regression models. To determine which variables would be included in the model, we used the backward method, with those variables with $p > 0.05$ being excluded. All study tests were performed with the IBM SPSS Statistics software package, version 20.0 (IBM Corporation, Armonk, NY, USA). Values of $p \leq 0.05$ were considered statistically significant.

RESULTS

Data on a total of 786 cases and described by 18 thoracic surgeons (mean number of resections per surgeon, 43.6) from 14 groups in various Brazilian states (São Paulo, Rio Grande do Sul, Rio de Janeiro, Ceará, Rio Grande do Norte, and Minas Gerais) and the Federal District of Brasília were compiled. Of those, 137 cases were excluded because of missing data that precluded analysis or because of inconsistencies, such as duplicate entries. Therefore, the study sample comprised 649 patients.

Study participant demographic data are detailed in Table 1. Most patients (n = 521; 89.8%) had undergone surgery for neoplastic disease. Non-neoplastic diseases are listed at the food of Table 1. In 69 cases, no data were available on diagnosis leading to surgery. Among the patients with cancer, the diagnosis was adenocarcinoma, in 369 (70.7%); squamous cell carcinoma, in 56 (10.6%); carcinoid tumors, in 46 (8.8%); large cell carcinoma, in 6 (1.5%); small cell carcinoma, in 2 (0.4%); secondary pulmonary neoplasia (metastases), in 29 (5.4%); and other types of neoplasia, in 14 (2.6%). In cases of primary pulmonary neoplasia, stage IA predominated, according to the clinical stage data for 425 patients and the pathological stage data for 483 patients. Neoplastic disease distribution by stage is detailed in Table 2.

Table 3 summarizes the surgical results observed in our study sample. Table 4 lists the intraoperative and postoperative complications reported in the databases. Conversion to thoracotomy was necessary in 30 cases (4.6%), and the reasons were hemorrhage, in 11 (37.9%); technical difficulties or prolonged operative time, in 9 (31.1%); and inadvertent bronchial injury, inadequate one-lung ventilation, and pleuropulmonary adhesions, in 3 cases each (10.3%). The reason for

Table 1. Demographic data of the 649 patients included in the study.[a]

Variable	Result
Age, years (n = 646)[b]	61.7 ± 14.7 (3-87)
Gender (N = 649)	
Male	295 (45.5)
Female	354 (54.5)
Diagnosis (n = 580)	
Neoplasia	521 (89.8)
Non-neoplasia[c]	59 (10.2)
Smoking status (n = 648)	
Nonsmoker	191 (29.5)
Smoker	269 (41.5)
Former smoker	188 (29.0)
Comorbidity	
COPD (n = 628)	234 (37.2)
Coronary artery disease (N = 649)	70 (10.8)
Congestive heart failure (N = 649)	22 (3.4)
Diabetes mellitus (n = 602)	85 (14.2)
Type of surgery (N = 649)	
Segmentectomy	35 (5.4)
Lobectomy	598 (92.1)
Bilobectomy	9 (1.4)
Pneumonectomy	7 (1.1)
Lobectomy (n = 598)	
Right upper	168 (28.1)
Middle	52 (8.7)
Right lower	113 (18.9)
Left upper	135 (22.6)
Left lower	125 (20.9)
No data	5 (0.8)

[a]Values expressed as n (%), except where otherwise indicated. [b]Value expressed as mean ± SD (minimum-maximum). [c]Suppurative disease (n = 37); lung malformation (n = 10); benign tumor (n = 6); bullous emphysema (n = 2); thrombosis of the middle lobe vein (n = 1); recurrent pneumothorax (n = 1); arteriovenous fistula (n = 1); and cryptococcosis (n = 1).

Table 2. Neoplastic disease stage.[a]

Stage	Clinical (n = 425)	Pathological (n = 483)
IA	244 (57.5)	235 (48.7)
IB	90 (21.2)	122 (25.2)
IIA	34 (8.0)	56 (11.6)
IIB	33 (7.7)	34 (7.0)
IIIA	14 (3.3)	30 (6.2)
IIIB	1 (0.2)	0 (0.0)
IV	9 (2.1)	6 (1.3)

[a]Values expressed as n (%).

Table 3. Surgical results.[a]

Variable	Result
Length of hospital stay (n = 570)[b]	4 (3-6)
Hospital stay longer than 7 days	103 (18.1)
Length of ICU stay (n = 606)[b]	1 (1-2)
Duration of drainage (n = 647)	3 (2-4)
Drainage longer than 7 days	53 (8.2)
Conversion to thoracotomy (N = 649)	30 (4.6)
Intraoperative complications (N = 649)	28 (4.3)
Postoperative complications (N = 649)	124 (19.1)
Reoperation (n = 495)	26 (5.2)
Readmission within 60 days (n = 495)	34 (6.9)
30-day mortality (n = 495)	10 (2.0)

[a]Values expressed as n (%), except where otherwise indicated. [b]Values expressed as median (interquartile range).

conversion to thoracotomy was not informed in 1 case. There was no intraoperative mortality in our sample.

Table 5 shows predictors of postoperative complications and 30-day mortality. Advanced age, male gender, heart failure, and intraoperative accidents increased the likelihood of postoperative complications, whereas advanced age and diabetes mellitus contributed to the likelihood of 30-day mortality. In the mortality analysis, we conducted a sensitivity test by removing the variable intraoperative complications and found no significant change in the values for the other variables, proving that the model was stable and independent of that variable.

DISCUSSION

In this multicenter study, we found, after analyzing 649 cases, an intraoperative complication rate of 4.3%. In 124 patients (19.1%), there were postoperative complications, totaling 241 complications (55 patients had 2 or more complications). The 30-day mortality rate was 2.0%, and the median hospital stay was 4 days. Among the predictors analyzed in our sample, advanced age and diabetes mellitus were found to influence mortality. The postoperative complication rate was also influenced by advanced age, as well as by male gender, heart failure, and intraoperative accidents.

Females predominated in our sample, which is in agreement with information contained in databases in the USA[15-17]; however, according to information contained in the European Society of Thoracic Surgeons (ESTS) database,[14] there is a predominance of males. The mean age in our sample was slightly lower in comparison with all the databases studied.[14-17] In our sample, the prevalence of heart failure and diabetes was higher than that reported in the Society of Thoracic Surgeons (STS) database[15] and in the ESTS database,[14] and the rates of coronary artery disease were higher than those reported in the ESTS database[14] but lower than those reported in the three databases from the USA.[15-17] These comparisons are detailed in Table 6.[18,21-23]

Table 4. Morbidity and (intraoperative and postoperative) complications.

Intraoperative complications (n = 28)	n (%)
Injury to a pulmonary artery and/or its branches	14 (50.0)
Injury to a pulmonary vein and/or its branches	6 (21.3)
Bronchial injury	4 (14.3)
Pulmonary parenchymal injury	1 (3.6)
Arrhythmia	1 (3.6)
Cardiopulmonary arrest	1 (3.6)
No data	1 (3.6)
Morbidity (n = 649)	
Patients without complications	525 (80.9)
Patients with complications	124 (19.1)
Patients with 1 complication	69 (10.6)
Patients with 2 complications	24 (3.7)
Patients with 3 or more complications	31 (4.8)
Postoperative complications	
Pneumonia	46 (7.1)
Prolonged air leaks (longer than 7 days)	36 (5.5)
Atelectasis	27 (4.2)
Arrhythmia	20 (3.1)
Empyema	17 (2.6)
Sepsis	17 (2.6)
Respiratory failure	16 (2.5)
Delirium	16 (2.5)
Acute kidney injury	14 (2.1)
ARDS	12 (1.8)
Surgical wound infection	7 (1.1)
Pulmonary thromboembolism	4 (0.6)
Deep vein thrombosis	2 (0.3)
Bronchial stump fistula	2 (0.3)
Acute myocardial infarction	1 (0.1)
Stroke	1 (0.1)
No data	3 (0.4)

The postoperative complication rate found in our study was lower than those reported in the ESTS database and in the STS database (19.1% vs. 29.1% and 26.23%, respectively),[14,15] which can in part be explained by the retrospective nature of the present study and by the possible loss of information or underreporting of complications, given that many of the patients included in the present study had undergone surgical treatment more than 5 years previously. Nevertheless, we found

higher rates of pneumonia, atelectasis, empyema, sepsis, respiratory failure, delirium, acute kidney injury, ARDS, surgical wound infection, deep vein thrombosis, and pulmonary thromboembolism than did those studies.[14,15] In contrast, the rates of prolonged air leaks, arrhythmia, acute myocardial infarction,

Table 5. Multivariate analysis.

Postoperative complications	OR	p	95% CI	β
Age	1.033	0.001	0.10-10.2	0.032
Female gender	0.489	0.003	0.23-8.98	-0.715
Congestive heart failure	3.617	0.005	0.46-7.76	1.286
Intraoperative accidents	2.685	0.02	0.42-5.41	0.988
30-day mortality				
Age	1.088	0.034	0.04-4.49	0.085
Diabetes mellitus	4.218	0.032	0.67-4.60	1.439

Table 6. Comparisons of demographic data, results, and postoperative complications among databases.

Variable	Database				
	VATS Brazil (N = 649)	ESTS[14] (N = 2,721)	STS[15] (N = 1,281)	SID[16] (N = 2,427)	Premier[17] (N = 295)
Gender, %					
Male	45.5	58.2	42.1	44	44.7
Female	54.5	41.8	57.9	56	55.3
Age, years, mean ± SD	61.7 ± 14.7	63.3 ± 11.3	65.1 ± 12.1	66.3	66.54
Smoking status, %					
Nonsmoker	29.5	-	74.63	-	-
Smoker	41.5	-	25.37	-	-
Former smoker	29.0	-	-	-	-
Comorbidity, %					
COPD	37.2	-	-	43	51.86
CAD	10.8	8.4	14.6	17	8.14
CHF	3.4	1.1	2.11	4	5.42
DM	14.2	13.9	11.0	16	20.34
Lobectomy, %					
Right upper	28.2	32.1	-	-	-
Middle	8.7	9.2	-	-	-
Right lower	19.5	17.4	-	-	-
Left upper	22.7	21.9	-	-	-
Left lower	20.9	17.4	-	-	-
30-day mortality, %	2.0	1.0	0.94	1.1	2.7
Postoperative complications, %	19.1	29.1	26.23	43.6	9.47
Length of hospital stay					
Median	4	6	4	5	4
Mean ± SD	6.75 ± 23.4	7.8 ± 5.8	-	-	5.83 ± 5.03
Pneumonia, n (%)	46 (7.1)	163 (6.0)	38 (2.97)	-	29 (9.83)
Prolonged air leaks, n (%)	36 (5.5)	275 (10.1)	97 (7.57)	-	70 (23.73)
Atelectasis, n (%)	27 (4.2)	65 (2.4)	27 (2.1)	-	43 (14.58)
Arrhythmia, n (%)	20 (3.1)	116 (4.3)	93 (7.26)	-	-
Empyema, n (%)	17 (2.6)	13 (0.5)	1 (0.08)	-	2 (0.68)
Sepsis, n (%)	17 (2.6)	-	6 (0.47)	-	-
Respiratory failure, n (%)	16 (2.5)	27 (1.0)	24 (1.88)	-	22 (7.46)
Delirium, n (%)	16 (2.5)	34 (1.2)	-	-	-
AKI, n (%)	14 (2.1)	9 (0.3)	-	-	-
ARDS, n (%)	12 (1.8)	20 (0.7)	9 (0.7)	-	-
Surgical wound infection, n (%)	7 (1.1)	6 (0.2)	3 (0.23)	-	0 (0.0)
PTE, n (%)	4 (0.6)	11 (0.4)	3 (0.23)	-	-
DVT, n (%)	2 (0.3)	-	2 (0.16)	-	-
AMI, n (%)	1 (0.1)	5 (0.2)	1 (0.08)	-	-
Stroke, n (%)	1 (0.1)	17 (0.6)	-	-	-

VATS: video-assisted thoracic surgery; ESTS: European Society of Thoracic Surgeons; STS: Society of Thoracic Surgeons; and SID: Seed Information Database. CAD: coronary artery disease; CHF: congestive heart failure; DM: diabetes mellitus; AKI: acute kidney injury; PTE: pulmonary thromboembolism; DVT: deep vein thrombosis; and AMI: acute myocardial infarction.

and stroke found in our study were low, which in part can be explained by the lower incidence of COPD and chronic arterial disease in our population (Table 6).

The number of infectious complications—empyema, pneumonia, or sepsis—in our sample is of note. One of the likely explanations is the fact that more than 15% of the patients included in our study had diseases associated with lung infections, such as bronchiectasis or tuberculosis, which could predispose to such complications and are less common in studies conducted in the USA and in Europe.[24] We were unable to statistically establish this correlation; however, the statistical power is low for this analysis. In any case, this is an indicator that should be paid attention to in the future.

In Brazil, there have been no studies describing complications of video-assisted thoracoscopic lobectomy; however, a study conducted at the Santa Casa Hospital Complex in Porto Alegre, located in the state of Rio Grande do Sul, Brazil, describes complications related to traditional lobectomy in lung donors.[25] In that study, 31.25% of the patients had one or more complications, the most common being pleural effusion.[25] Another study conducted in the same state, also regarding lobectomy via thoracotomy, reported a complication rate of 44%, in addition to an intraoperative mortality rate of 2.9%.[26] The mean age of those patients, 63.7 ± 9.7 years, was similar to that found in our sample; however, most of those patients (83.9%) had one or more comorbidities, and 90% had a history of smoking. The most common complication was air leaks.[26] A lower complication rate, 18.6%, was documented in a study conducted by the State University at Campinas; however, in the study, there were other procedures that did not involve resection of lung parenchyma.[27]

Our study has limitations, and the most significant is its retrospective design. As previously mentioned, we may have underestimated the actual number of complications occurring in the cases studied. In addition, we cannot classify the severity of the complications observed, since the definition of which was determined *a posteriori* and the data in the medical records were very heterogeneous. The present study included cases on the learning curve of most participating surgeons (with up to 50 cases per surgeon)[28]; therefore, if, on one hand, less experience might lead to a greater number of complications, on the other, favorable cases are likely to have been selected. In addition, the participation of surgeons was voluntary, so it is possible that the surgeons participating in the study do not fully represent all thoracic surgery groups in Brazil. Furthermore, although the data were collected and organized by only one researcher, each surgeon was responsible for their database and there may therefore be heterogeneity in the data provided.

As shown in the present study, anatomic pulmonary resections by video-assisted thoracoscopy have been performed at several centers throughout Brazil. The results of these surgeries, which represent the results for the learning curve of the several centers and therefore constitute the critical mass regarding video-assisted resections in our country, are consistent with the results observed in large international databases. Since the technique has been safely and successfully implemented in the participating institutions, strategies should be developed to increase access to this minimally invasive alternative. Advanced age and heart failure, which are preoperative predictors of complications, should be taken into account when considering this type of surgery.

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