

Early postoperative pulmonary complication profile and selective non-invasive ventilation after multivessel bypass surgery via left anterior minithoracotomy

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Received: 20/11/2025; Accepted: 21/01/2026; Published: 25/02/2026

Abstract

Objective: Minimally invasive multivessel coronary bypass performed through a left anterior minithoracotomy may be associated with early postoperative respiratory events related to thoracotomy, one-lung ventilation, and perioperative ventilatory management. This study aimed to describe the early postoperative pulmonary complication profile in our center and to report the use of selective postoperative non-invasive mechanical ventilation (NIMV) in routine clinical practice. **Method:** This single-center retrospective descriptive study included 77 consecutive patients who underwent minimally invasive on-pump multivessel coronary bypass surgery through a left anterior mini-thoracotomy between January 2022 and December 2024. Patients were evaluated for early postoperative pulmonary complications documented in the clinical record and chest radiography, including atelectatic changes, pleural effusion, pneumonia, decreased partial oxygen pressure (PaO_2), and blunting of the costophrenic angle. Preoperative spirometry was obtained when clinically feasible. **Results:** Seventy-seven patients (44–79 years; mean age 58.2 years) were included. Preoperative spirometry was available in 51 patients. Five patients required postoperative NIMV because of radiographic and/or oxygenation findings during follow-up; in two of these patients, intermittent ward NIMV was administered for $SpO_2 < 92\%$ and $PaO_2 < 70$ mmHg, with subsequent improvement in oxygen saturation to $> 94\%$ after NIMV sessions and mobilization. Postoperative pneumonia occurred in one patient and pleural effusion in two patients; no thoracentesis was required. Mean room-air discharge values were acceptable at cohort level (Table 5), with PaO_2 99 mmHg, $PaCO_2$ 34 mmHg, and SpO_2 94%. **Conclusion:** In this selected retrospective cohort, early postoperative pulmonary complications after minimally invasive multivessel bypass surgery were infrequent and were managed predominantly with conservative treatment; selective NIMV was used in a small subset of patients as rescue support. The present data support feasibility reporting only and do not establish NIMV efficacy. Prospective comparative studies with standardized postoperative pulmonary assessments are needed.

Keywords: Minimally invasive cardiac surgery, postoperative non-invasive mechanical ventilation, MIDCAB, coronary artery bypass grafting

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Introduction

Minimally invasive cardiac surgery has gained wide acceptance because, in selected patients, it can reduce surgical trauma, shorten recovery time, and improve cosmetic outcomes compared with median sternotomy [1]. Despite these advantages, thoracotomy-based approaches may still be associated with clinically relevant postoperative pulmonary complications, particularly in the early period after surgery [2]. In procedures performed through a left anterior

minithoracotomy, one-lung ventilation, local pain, altered ventilatory mechanics, pleural drainage, and cardiopulmonary bypass (CPB) may all contribute to transient postoperative respiratory impairment and delayed recovery. Preoperative pulmonary risk assessment is therefore important, especially in patients with suspected chronic obstructive pulmonary disease (COPD) or reduced pulmonary reserve [3].

In our clinical practice, multivessel minimally invasive bypass surgery is performed using a double-

lumen endotracheal tube to permit one-lung ventilation during key operative steps. We frequently observe transient postoperative radiographic and oxygenation abnormalities, but the routine use, optimal indications, and expected benefit of postoperative non-invasive mechanical ventilation (NIMV) in this setting remain insufficiently standardized. In the intensive care unit, ventilatory support is individualized, and positive end-expiratory pressure (PEEP) is adjusted according to gas exchange and hemodynamic tolerance.

Accordingly, the aim of this study was not to measure postoperative pulmonary function capacity directly, but to describe the early postoperative pulmonary complication profile, blood gas findings, and selective NIMV requirements in patients undergoing minimally invasive multivessel bypass surgery via left anterior minithoracotomy.

Methods

This was a single-center retrospective descriptive cohort study of patients who underwent minimally invasive on-pump multivessel coronary bypass surgery via left anterior thoracotomy (4th intercostal space) between January 2022 and December 2024. The primary objective was to describe early postoperative pulmonary complications and the use of selective NIMV after extubation. Patients who underwent redo surgery, emergency surgery, combined cardiac procedures, or who had a porcelain aorta, advanced chronic obstructive pulmonary disease (COPD) / significant pulmonary disease, or chronic kidney failure were excluded, as summarized in Table 1. During the preoperative period, all patients underwent thoracic and pelvic computed tomography to assess peripheral artery disease, aortic calcification, and the heart-thorax relationship. Based on these evaluations, the cannulation strategy was selected, with axillary cannulation preferred in patients with peripheral arterial disease. Regardless of pulmonary function test results, all patients received inhaled ipratropium bromide and budesonide at six-hour intervals preoperatively. Preoperative spirometry was performed when clinically feasible; patients with unstable coronary syndromes and critical coronary lesions who required expedited surgery could not always undergo testing. For this reason, spirometry data were available for a subset of the cohort and were analyzed descriptively without imputation. Pulmonary complications, chest radiographic findings, arterial blood gas measurements, and NIMV use were obtained from routine perioperative records. Because the study had no com-

parator arm and was not powered for causal inference, analyses were limited to descriptive summaries (means with standard deviations for continuous variables and counts/proportions for categorical findings). This retrospective observational study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the relevant health authorities and institutional review board (Hisar International Hospital Local Ethics Committee; date: 01.12.2023; decision no:23-56). All procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all individual participants included in the study.

Table 1: Inclusion / exclusion criteria

Exclusion criteria	Inclusion criteria
Redo bypass	Multivessel coronary artery disease
Emergency bypass	Critical left main coronary artery disease
Porcelain aorta	
Combined valve surgery	
Advanced COPD and pulmonary disease	
Chronic kidney failure	

Anesthetic management

Patients received 3 mg melatonin the night before surgery. After entering the operating room, midazolam (0.03 mg/kg) was administered for premedication. Anesthesia was induced with midazolam (0.01–0.5 mg/kg), fentanyl (2–7 µg/kg), rocuronium (0.5–1 mg/kg), and propofol (1.5–2.5 mg/kg). All patients were intubated with a double-lumen endobronchial tube to facilitate one-lung ventilation, and tube position was confirmed by fiberoptic bronchoscopy. After intubation, volume-controlled mechanical ventilation was used with a tidal volume of 4–6 mL/kg, an inspiratory-to-expiratory ratio of 1:2, a respiratory rate of 12/minute, and a PEEP of 5 cm H_2O . The same anesthesia device (Aisys CS2, GE, Datex-Ohmeda, General Electric, USA) was used for all patients. Anesthesia was maintained with an oxygen/medical air mixture (40–50% FiO_2), sevoflurane, and continuous remifentanyl infusion. A low-flow anesthesia technique was used, with sevoflurane

administered at a minimum alveolar concentration (MAC) of 1 and a fresh gas flow rate of 0.5 L/min.

Under ultrasound guidance, an 8.5F central venous catheter was placed in the left internal jugular vein for central venous pressure monitoring. Depth of anesthesia was continuously monitored using Entropy® (GE, General Electric, USA), particularly during CPB, to maintain adequate anesthetic depth. Intermittent bolus doses of fentanyl, midazolam, and propofol were administered as needed. During CPB, the total fentanyl dose was limited to a maximum of 20 µg/kg.

Surgical procedure

Patients were positioned supine on the operating table. A 5–7 cm skin incision was made in the 4th intercostal space for the left anterior minithoracotomy. During preparation of the left internal thoracic artery (LITA), one-lung ventilation was initiated. A special retractor (Delacroix-Chevalier, Paris, France) was used to optimize exposure. Cannulation was performed through 3–4 cm incisions using the femoral artery or axillary artery together with the femoral vein. Arterial cannulation was achieved with 17–21F cannulas and venous cannulation with 22–26F cannulas (Medtronic DLP, Grand Rapids, MI, USA). For additional anastomoses, saphenous vein grafts were harvested using 2 cm sequential incisions. The space between the aorta and pulmonary artery was dissected, and a 10 mm teflon tape was looped around the aorta for traction. Cardioplegia was administered using a long antegrade cardioplegia cannula (MiAR™ Cannulae, Medtronic, USA). A Chitwood DeBakey Clamp (Scanlan® International Inc., Saint Paul, MN, USA) was applied at the 2nd intercostal space of the left anterior axillary line for cross-clamping. Distal bypasses were performed using saphenous vein grafts and the LITA graft. After completion of distal anastomoses, the cross-clamp was removed. A side clamp was then applied at the aortic incision site, and proximal anastomoses were completed using traction with teflon tape. After hemostasis, the double-lumen endotracheal tube was replaced with a single-lumen tube and the patient was transferred to the intensive care unit [4].

All patients were routinely evaluated by the cardiovascular surgery and anesthesiology teams on the evening of the operation and were subsequently extubated when clinically appropriate (mean ventilation time: 6 hours). Extubation decisions were based on bleeding volume, urine output, hemodynamic parameters (rhythm and blood pressure), and arterial blood

gas analysis.

Routine NIMV was not administered after extubation. While patients remained intubated in the early postoperative period, PEEP was generally maintained at 6–8 cm H₂O according to clinical status. After extubation, patients were monitored for pulmonary complications, including pleural effusion, atelectatic changes, and blunting of the costophrenic angle, using clinical examination, arterial blood gas analysis, oxygen saturation monitoring, and chest radiography. Atelectatic segments and costophrenic angle blunting were identified on chest radiographs reported during routine care. NIMV was used selectively as rescue support in patients with radiographic abnormalities and/or impaired oxygenation, and serial arterial blood gas analyses were used to assess response.

Results

Between January 2022 and December 2024, a total of 77 patients underwent minimally invasive coronary bypass surgery via left anterior minithoracotomy. Of these, 53 were male and 24 were female. The patients' ages ranged from 44 to 79 years, and the mean age was 58.2 years. The demographic characteristics of the patients are summarized in Table 2.

Table 2: Demographic data of the patients

Characteristics	Value (total patient, n=77)	
	n	%
Male	53	
Female	24	
Age (Mean ± SD)	58.2 ± 22	
Smoker	32	41.5
Hypertension	28	36.3
Diabetes mellitus	37	48
Hyperlipidemia	24	31.1
Bmi > 30	1	0.012

Preoperative pulmonary status was assessed using spirometry when clinically feasible. Spirometry could not be performed in some patients presenting with non-ST-elevation myocardial infarction (NSTEMI) or unstable angina pectoris (USAP) and critical coronary artery lesions because delaying surgery for testing was not considered appropriate. Accordingly, pulmonary function testing was available in 51 patients and missing in 26 patients. Patients with advanced COPD or significant pre-existing pulmonary disease were excluded from the study; therefore, Ta-

ble 3 should be interpreted as a descriptive summary of a selected subset rather than a full-cohort comparison.

Table 3: Pulmonary function test results

FVC	3.9± 0.7
FEV1	3.0 ± 0.5
FEV1/FVC	75.5 ± 7.1
PEF	4.9 ± 1.5
MEF75	4.7 ± 1.3
MEF50	3.4 ± 0.7
MEF25	1.1 ± 0.3
MEF25-75	2.8 ± 0.5
FVC: Forced vital capacity, FEV: Forced expiratory volume, PEF: Peak expiratory flow MEF: Mean expiratory flow	

All included patients underwent minithoracotomy coronary bypass surgery for isolated multivessel coronary artery disease; patients requiring additional cardiac procedures were excluded by design. The intraoperative and postoperative descriptive data are summarized in Table 4. No formal between-group comparisons were performed because no comparator cohort was included.

Table 4: Intraoperative and post-operative data

Characteristics	Value
X-klomp(min)	83.1±12.2
CPB(min)	141.1±18.3
Blood transfusion(unit)	1.7±0.8
Ventilation time, mean±SD (hours)	5.8±2.1
ICU length of stay (day)	1.1±0.4
Hospital length of stay (day)	4.8±1.1
CPB: Cardiopulmonary bypass , ICU: Intensive care unit	

Five patients required NIMV during postoperative follow-up because of radiographic costophrenic angle blunting and/or impaired oxygenation (5/77, 6.5%). In two patients (2/77, 2.6%), *SpO₂* was below 92% and *PaO₂* was below 70 mmHg, and intermittent NIMV was administered during in-hospital follow-up. After approximately 2–3 NIMV sessions combined with mobilization, *SpO₂* improved to above 94% in these patients. Postoperative pneumonia was detected in one patient (1/77, 1.3%), who was discharged following a 10-day course of antibiotic therapy. Pleural effusion was observed in two patients (2/77, 2.6%), but thoracentesis was not required. Mean arterial blood gas values and vital signs on the

day of discharge are summarized in Table 5; room-air values were within clinically acceptable ranges at the cohort level.

Postoperative bleeding occurred in one patient (1/77, 1.3%) and required surgical revision. No cases of postoperative myocardial infarction were observed. Atrial fibrillation developed in five patients (5/77, 6.5%) and was successfully converted to sinus rhythm with medical treatment. No postoperative mortality occurred. Most patients were discharged within 5 to 7 days postoperatively, consistent with the descriptive length-of-stay data in Table 4. Given the small sample size and low event counts, these frequencies should be interpreted as imprecise descriptive estimates rather than stable incidence measures.

Table 5: Mean blood gas values and vital signs on discharge day

Characteristics	Value, mean (SD)
PaO ₂ (mmHg)	99 (18.1)
Arterial (pH)	7.38(0.05)
PaCO ₂ (mmHg)	34(2.4)
Mean arterial blood pressure, mean (SD) (mmHg)	74(11.2)
Heart rate (min)	89(13.2)
Saturation O ₂ (%)	94(4.2)

Discussion

With recent advancements in cardiovascular surgery, there has been a notable shift toward minimally invasive cardiac procedures. Minimally invasive bypass surgery performed via thoracotomy at the fourth intercostal space—without sternotomy—can reduce surgical trauma, improve cosmetic outcomes, and facilitate faster mobilization in appropriately selected patients. However, thoracotomy-based multivessel coronary bypass also introduces procedure-specific respiratory risks related to one-lung ventilation, pleural manipulation, pain-limited respiratory effort, and cardiopulmonary bypass. The present study therefore focuses on early postoperative pulmonary events and supportive respiratory management rather than on long-term functional outcomes.

Multivessel coronary bypass surgery performed via thoracotomy is technically demanding and is associated with a learning curve. Even in experienced hands, pulmonary and pleural complications may occur and can delay recovery if not recognized early. Our contribution is to report the frequency and short-

term clinical course of these events in a selected cohort managed with an individualized postoperative respiratory strategy, rather than to claim superiority over conventional sternotomy or over alternative perioperative ventilation protocols [5, 6].

In minimally invasive bypass surgery via thoracotomy, distal anastomosis technique is similar to conventional surgery, but exposure requires a different access route, specialized retractors, and one-lung ventilation. During LITA harvesting and coronary anastomosis, interruption or reduction of ventilation to improve operative exposure may contribute to transient atelectatic change. In addition, pleural manipulation and postoperative pain can impair deep inspiration and cough, which may promote early radiographic abnormalities. These mechanisms provide a plausible basis for the postoperative findings observed in our cohort, but they were not directly measured in this study.

Prolonged operative duration or traumatic tissue handling may increase the risk of postoperative pleural or pulmonary complications. In this context, chest radiographic findings such as increased hemithoracic opacity, costophrenic angle blunting, or reduced lung expansion should be interpreted together with symptoms, oxygen saturation, and arterial blood gas values. Importantly, radiographic costophrenic angle blunting by itself does not necessarily indicate clinically significant pleural effusion requiring intervention. In our series, some radiographic abnormalities were managed conservatively and no thoracentesis was required, which supports careful clinical-radiographic correlation in postoperative decision-making.

For patients undergoing coronary artery bypass grafting (CABG), preoperative recognition of COPD and estimation of pulmonary reserve remain important components of perioperative planning [7]. In our cohort, spirometry could not be completed in all patients because urgent surgery was prioritized in some patients with NSTEMI/USAP and critical coronary anatomy. This missingness was clinically driven and therefore likely non-random. Consequently, the spirometry values in Table 3 should not be interpreted as representative of the entire cohort, and no comparative conclusions regarding spirometric predictors can be drawn from the present dataset. Nevertheless, the practical difficulty of obtaining spirometry in unstable patients is itself an important real-world observation.

Deterioration in oxygenation may impair tissue perfusion and can complicate recovery after cardiac

surgery [8]. In our postoperative practice, NIMV was not applied routinely; instead, it was used selectively as rescue support in a small subset of patients with radiographic abnormalities and/or reduced oxygenation. The observed improvement in oxygen saturation after NIMV sessions and mobilization in two patients is clinically encouraging, but it should not be interpreted as proof of efficacy because there was no comparator group, indications were not protocolized, and spontaneous improvement with mobilization and routine care cannot be excluded. This interpretation is consistent with the mixed literature regarding perioperative positive-pressure strategies and the heterogeneity described in prior studies [9].

The primary goal of minimally invasive approaches is to improve recovery and patient comfort by minimizing surgical trauma. In addition, we performed endoscopic saphenous vein harvesting in eligible patients. No leg infections were observed in our cohort, including patients with common risk factors such as diabetes. This observation is descriptive only and should not be overgeneralized. The balance between potential benefits of endoscopic harvesting and concerns regarding conduit quality and long-term patency remains an area in which surgeon experience and case selection are important, and the current literature continues to evolve [10].

Although severe COPD is not universally considered an absolute contraindication to minimally invasive coronary surgery, patient selection and intraoperative tolerance of one-lung ventilation remain critical [11]. Our study excluded patients with advanced COPD/significant pulmonary disease, so we cannot draw conclusions about safety or NIMV effectiveness in that subgroup. Similarly, the present cohort does not support subgroup conclusions in obese patients because only one patient in Table 2 had BMI >30. Therefore, statements regarding obese or advanced COPD populations should be regarded as hypotheses for future studies rather than evidence generated by the current series [13].

Katiyar et al. reported early postoperative impairment in forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC), with several risk factors associated with poorer short-term pulmonary function [12]. These findings support the broader rationale for perioperative respiratory optimization and careful postoperative surveillance. However, our study did not perform postoperative spirometry and therefore cannot directly quantify postoperative pulmonary function decline, recovery trajectory, or associations between CPB time and spirometric changes.

The present data should be interpreted as event-based clinical observations, not physiological lung function measurements.

When all postoperative pulmonary outcomes are considered together in our cohort, most events were managed conservatively, invasive pleural intervention was not required, and selective NIMV was used in a small number of patients. At the same time, the occurrence of pneumonia and pleural effusion in a minority of patients confirms that pulmonary complications were not absent and require ongoing surveillance. Previous studies indicating persistent postoperative pulmonary function impairment after cardiac surgery remain relevant when planning follow-up and rehabilitation [14, 15].

The main limitations of this study are its retrospective design, single-center setting, small sample size, selected patient population, absence of a comparator group, non-standardized NIMV indications, and incomplete preoperative spirometry data. In addition, event counts were low, which limits precision and precludes robust statistical inference. For these reasons, our findings should be used to inform hypothesis generation and protocol development rather than to support causal claims about the effectiveness of NIMV or other perioperative interventions.

Conclusion

Minimally invasive multivessel coronary bypass surgery via left anterior minithoracotomy was feasible in this selected cohort and was associated with a low frequency of early postoperative pulmonary events managed predominantly with conservative measures. Selective postoperative NIMV was used in a small subset of patients with radiographic abnormalities and/or oxygenation impairment and was followed by short-term clinical improvement, but the present retrospective descriptive design does not permit efficacy conclusions. Preoperative spirometry remains useful when clinically feasible, yet urgent coronary presentations may limit its availability. Prospective studies with standardized complication definitions, protocolized NIMV indications, serial postoperative pulmonary function assessment, and appropriate comparator groups are needed to determine which patients benefit most from specific respiratory support strategies.

Human ethics and consent to participate declarations

This retrospective observational study was conducted in accordance with the principles of the Declaration

of Helsinki and was approved by the relevant health authorities and institutional review board (Hisar International Hospital Local Ethics Committee; date: 01.12.2023; decision no:23-56). All procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all individual participants included in the study.

Clinical trial number

Not applicable.

Informed consent

Informed consent was obtained from the participants.

Financial disclosure

The authors have not provided financial support.

Conflict of interest

No conflicts of interest were declared by the authors.

References

- [1] Babliak, Oleksandr, et al. "Complete coronary revascularization via left anterior thoracotomy." *Innovations* 14.4 (2019): 330-341.
- [2] Sicim, Hüseyin, et al. "Comparison of postoperative outcomes between robotic mitral valve replacement and conventional mitral valve replacement." *Journal of Cardiac Surgery* 36.4 (2021): 1411-1418.
- [3] Saçlı, H., and M. S. Diler. "The Effect of Pulmonary Function Tests on Mortality and Morbidity in Open-Heart Surgery Patients Undergoing Cardiopulmonary Bypass." *Koşuyolu Heart Journal*, vol. 22, no. 2, 2019, pp. 85–90.
- [4] Sicim, Hüseyin, and Ali Fedakar. "Post-Operative Continuous Positive Airway Pressure Therapy Experience in Patients Undergoing Minimal Invasive Multivessel Coronary Artery Bypass Grafting Through Left Anterior Mini-Thoracotomy." *Journal of Cardio-Vascular-Thoracic Anaesthesia and Intensive Care Society* 28.3 (2022): 276-281.
- [5] Mali, Shahriar, and Hasan Haghaninejad. "Pulmonary complications following cardiac surgery." *Archives of Medical Science-Atherosclerotic Diseases* 4.1 (2019): 280-285.
- [6] Rodriguez, Maria Lorena, et al. "Mid-term follow-up of minimally invasive multivessel coronary artery bypass grafting: is the early learning phase detrimental?." *Innovations* 12.2 (2017): 116-120.

- [7] Badak, Tolga Onur, and Ahmet İhsan İşkesen. "Koroner arter cerrahisinin solunum fonksiyonlarına etkilerinin solunum fonksiyon testi ile değerlendirilmesi." *Celal Bayar Üniversitesi Sağlık Bilimleri Enstitüsü Dergisi* 8.2 (2021): 331-336.
- [8] Lighthall, Geoffrey Kenton, and Sumit Singh. "Perioperative maintenance of tissue perfusion and cardiac output in cardiac surgery patients." *Seminars in Cardiothoracic and Vascular Anesthesia*. 18.2 (2014): 117–136
- [9] Wang, Yi-Chia, Chi-Hsiang Huang, and Yu-Kang Tu. "Effects of positive airway pressure and mechanical ventilation of the lungs during cardiopulmonary bypass on pulmonary adverse events after cardiac surgery: a systematic review and meta-analysis." *Journal of Cardiothoracic and Vascular Anesthesia* 32.2 (2018): 748-759.
- [10] ARITÜRK, Cem, et al. "Cerrah Deneyimi Endoskopik Safen Ven Grefti Hazırlanmasında Komplikasyon Oranını Azaltıyor." *Journal of the Society of Thoracic Carido-Vascular Anaesthesia & Intensive Care* 21.3 (2015): 147-151.
- [11] Wu, C. T., et al. "Lung function influenced the prognosis of cardiac surgery in patients with chronic obstructive pulmonary disease." *Zhonghua jie he he hu xi za zhi= Zhonghua jiehe he huxi zazhi= Chinese Journal of Tuberculosis and Respiratory Diseases* 40.2 (2017): 86-89.
- [12] Katiyar, Neetika, et al. "Assessment of factors affecting short-term pulmonary functions following cardiac surgery: A prospective observational study." *Asian Cardiovascular and Thoracic Annals* 30.2 (2022): 156-163.
- [13] Li, Hsueh-Yu, et al. "How to manage continuous positive airway pressure (CPAP) failure–hybrid surgery and integrated treatment." *Auris Nasus Larynx* 47.3 (2020): 335-342.
- [14] de Oliveira Gomes, Débora Santos, et al. "Impact of drains positioning on pulmonary function after coronary artery bypass grafting: an observational study." *Brazilian Journal of Anesthesiology (English Edition)* 72.1 (2022): 83-87.
- [15] İnönü, Handan. "The effects of heart surgery on early and late pulmonary functions: The results of three-year follow-up." *Turkish Journal of Thoracic and Cardiovascular Surgery* 19.2 (2011): 144-150.