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One Lung Ventilation (OLV) Effects on Troponin T and I Levels in Thoracic Surgical Procedures

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Article

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Abstract

Objectives

The one-lung ventilation (OLV) technique offers significant operative advantages but may cause various physiological complications that can potentially affect cardiovascular function. Intraoperative hemodynamic changes may lead to postoperative myocardial infarction and increased mortality risk.

Design :

This research is cohort study. The method of selecting subjects in this study was consecutive sampling. The retrieval or search for the subject continued until the desired subject sizes were achieved.

Setting :

Prof. Dr. Margono Soekarjo Hospital

Participant :

39 patients who underwent thoracic surgery with OLV at and met the inclusion criteria.

Measurement :

All participants received OLV with a ventilation ratio of 50% air to 50% oxygen, tidal volume of 5–6 mL/kg body weight, and respiratory rate of 12 breaths/min. Troponin T and I levels were measured preoperatively and postoperatively. The hemodynamic status and perioperative parameters were recorded.

Results

Postoperative troponin T (8.19 ± 2.43 vs. 6.32 ± 1.19 ng/L; $p < 0.001$) and troponin I (57.02 ± 17.33 vs. 49.84 ± 16.30 ng/L; $p < 0.001$) levels were significantly higher than preoperative values. Multivariate analysis revealed that postoperative PaO_2 (Troponin T; B = 0,530; p = 0,002) (Troponin I; B = 0,544; p = 0,013) was the most influential factor affecting postoperative troponin levels.

Conclusion

Patients undergoing thoracic surgery with OLV exhibited a significant postoperative increase in troponin T and I levels. Postoperative PaO_2 was identified as a key factor influencing postoperative troponin concentrations.

Introduction

Postoperative myocardial infarction is a significant complication with varying incidences depending on the type of surgery and the patient's risk factors. In major surgeries, the incidence of PMI ranges from 0.37% to 2.4%, with a 30-day mortality rate of 1.04% (Huang et al., 2020). The PMI risk increased gradually with additional risk factors, ranging from 0.42% with one risk factor to 1.08% with three or more risk factors. Important risk factors associated with PMI include a history of myocardial infarction (MI), where surgery performed within 8 weeks after MI significantly increases the risk of PMI and postoperative mortality. Thoracic surgery is a complex procedure that requires specialized anesthesia management to facilitate optimal surgical access to the intrathoracic structures. The *one-lung ventilation* (OLV) technique has become the standard in thoracic surgical anesthesia, allowing collapse of the surgical lung, thereby improving visualization and surgical access to the surgical field. Although this technique provides significant operative advantages, OLV can cause various physiological complications that can affect a patient's cardiovascular function.

Troponin T and troponin I are the most sensitive and specific cardiac *biomarkers* for detecting myocardial injury. These two structural proteins are exclusively found in the heart muscle and are released into the circulation when myocardial cell damage occurs, even at the subclinical level. Elevated troponin levels may indicate *procedure-related myocardial injury* or perioperative myocardial infarction, both of which are associated with increased postoperative morbidity and mortality. This study aimed to determine the relationship between the One Lung Ventilation (OLV) technique and Troponin T and I levels in Thoracic Surgery Procedures at Prof. Dr. Margono Soekarjo Purwokerto Hospital.

Methods

This analytical observational study, with a prospective cohort design and a *single-group cohort*, analyzed the relationship between the One Lung Ventilation (OLV) technique and Troponin T and I levels in thoracic surgical procedures at Prof. Dr. Margono Soekarjo Purwokerto Hospital. The method of selecting subjects in this study was *consecutive sampling*, a nonprobability sampling method in which all eligible patients who met the research criteria were included as subjects. The retrieval or search for the subject continued until the desired subject sizes were achieved. All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all subjects and/ or their legal guardian.

This study was approved by the Medical Research Ethics Commission (registration number 108/KEPK/PE/IX/2025) on September 18, 2025. This study was registered at clinicaltrials.gov under the

registration number NCT07302243. All matters related to research data can be seen in https://data.mendeley.com/ with DOI: 10.17632/xp7hc44dzz.1.

Result

Analysis of the characteristics of the study participants showed that the average age of the study participants was 45.25 ± 12.94 years, the majority were male (n = 31; 79.5%), had a normal BMI value (21.22 ± 2.57 kg/m2), and underwent decorticizing thoracotomy surgery (n = 25; 64.1%). The average preoperoperative troponin T level in the study subjects was 6.32 ± 1.19 ng/L, and the average troponin I level was 49.84 ± 16.30 ng/L The patient underwent surgery for 193.07 ± 36.68 minutes, and the duration of OLV use was 42.94 ± 12.39 minutes (Table 1)

Table 1
Subject characteristic

Characteristic	Mean ± SD	Median (Min-Max)
Age (Years)	45,25 ± 12,94	49 (18–60)
Sex (n,%) Male Women	 31 8	 79,5% 20,5%
BMI (kg/m^2)	21,22 ± 2,57	20,3 (16,1–27,1)
PaO2 preoperatives (mmHg)	66,92 ± 11,91	68,9 (20,10–87)
Preoperative PaCO2 (mmHg)	36,04 ± 7,97	33,6 (23,4–56,3)
Types of Operations Decortication Lobectomy	 25 14	 64,1% 35,9%
Systolic Blood Pressure (mmHg)	138,10 ± 15,37	136 (107–171)
Diastolic Blood Pressure (mmHg)	81,76 ± 8,78	80 (65–104)
Pulse rate (x/min)	88,48 ± 12,77	88 (69–115)
Respiratory rate (x/min)	15,30 ± 1,50	15 (14–18)
SpO2 (%)	97,00 ± 0,82	97 (96–98)
Duration of Operation (Menit)	193,07 ± 36,68	180 (120–270)
Duration OLV (Menit)	42,94 ± 12,39	45 (30–80)
Intraoperative bleeding (mL)	380,76 ± 167,65	300 (100–800)
MAP during surgery (mmHg)	99,23 ± 8,26	98 (81–119)
Hb postoperative (g/dL)	11,51 ± 1,84	11,4 (8,4–15,4)
PaO2 postoperasi (mmHg)	77,83 ± 8,01	75,4 (66–99)
Postoperative PaCO2 (mmHg)	49,62 ± 14,30	47,1 (25,5–82)
Preoperative Troponin T (ng/L)	6,32 ± 1,19	6,3 (3,47 – 10,43)
Preoperative troponin I (ng/L)	49,84 ± 16,30	47 (5-108)
Troponin T postoperative (ng/L)	8,19 ± 2,43	7,44 (5,82 – 18,63)
Postoperative Troponin I (ng/L)	57,02 ± 17,33	51 (44–121)

The differences in troponin T and I levels between the preoperative and postoperative troponin levels are presented in Table 2. The average preoperative troponin T levels in the study participants were 6.32 ± 1.19 ng/L, and postoperative levels were 8.19 ± 2.43 ng/L. The Wilcoxon test showed a significant difference in preoperative and postoperative troponin T levels ($p < 0.001$). The average preoperative troponin I levels in the study subjects were 49.84 ± 16.30 ng/L, and the postoperative level was 57.02 ± 17.33 ng/L. The Wilcoxon assay showed a significant difference in preoperative and postoperative troponin I levels ($p < 0.001$).

Table 2
Analysis of troponin T and I levels

Variable	**Mean ± SD**	**Median (Min-Max)**	**p**
Preoperative Troponin T (ng/L)	6,32 ± 1,19	6,3 (3,47 – 10,43)	< 0,001*
Troponin T postoperative (ng/L)	8,19 ± 2,43	7,44 (5,82 – 18,63)	
Preoperative troponin I (ng/L)	49,84 ± 16,30	47 (5-108)	0,017*
Postoperative Troponin I (ng/L)	57,02 ± 17,33	51 (44–121)	
Remarks : * significant (p < 0,05)			

A bivariate analysis of factors that could affect troponin T and troponin I levels is presented in Table 3. The results showed that from the analyzed factors, the values of MAP during surgery ($p < 0.001$), diastolic blood pressure ($p < 0.001$), duration of OLV ($p < 0.001$), postoperative hemoglobin levels ($p < 0.001$), intraoperative bleeding ($p < 0.001$), postoperative PaO_2 ($p < 0.001$), and postoperative $PaCO_2$ ($p < 0.001$) were significantly correlated with troponin T and troponin I levels.

Table 3
Bivariate analysis of factors affecting troponin T and I

Variable	Troponin T		Troponin I	
	r	p	r	p
MAP during surgery	-0,715	< 0,001*	-0,616	< 0,001*
Systolic during surgery	0,219	0,180	0,081	0,625
Diastolic during surgery	-0,721	< 0,001*	-0,579	< 0,001*
Pulse rate	0,288	0,076	0,298	0,066
OLV duration	0,760	< 0,001*	0,673	< 0,001*
Postoperative Hb	-0,533	< 0,001*	-0,354	0,027*
Intraoperative bleeding	0,605	< 0,001*	0,613	< 0,001*
Postoperative PaO2	0,842	< 0,001*	0,797	< 0,001*
Postoperative PaCO2	-0,620	< 0,001*	-0,575	< 0,001*
Remarks : *significant (p < 0,05)				

A multivariate analysis of the factors that can affect troponin T and troponin I levels is presented in Table 4. The results showed that among the influencing factors, only postoperative PaO2 affected the troponin T and I levels.

Table 4
Multivariate analysis of factors affecting troponin T and I

Variable	Troponin T		Troponin I	
	B	p	B	p
Postoperative MAP	-0,167	0,183	-0,118	0,460
Duration of OLV	0,123	0,392	0,162	0,380
Postoperative Hb	-0,089	0,391	0,111	0,403
Intraoperative bleeding	0,020	0,869	0,191	0,234
Postoperative PaO2	0,530	0,002*	0,544	0,013*
Postoperative PaCO2	0,037	0,778	0,074	0,659
Diastolic during surgery	-0,189	0,164	-0,055	0,758
Remarks : B, coefisient ; * significant (p < 0,05)				

Discussion

This study was conducted on 39 patients who underwent thoracotomy with OLV at Prof. Dr. Margono Soekarjo Purwokerto Hospital. In general, the demographic characteristics of the study participants indicated results that fell within the normal range. This study analyzed the effect of OLV on troponin T and I levels in patients who underwent thoracotomy. The results showed a statistically significant difference in troponin T and I levels ($p < 0.05$), indicating that postoperative levels were significantly higher than preoperative ones. Several factors affect such as MAP, systolic and diastolic blood pressure during surgery, pulse rate, duration of OLV, HB postoperatively, intraoperative bleeding, and postoperative PaO2 and PaCO2.

Thoracotomy is known to have a significant risk of side effects on the cardiovascular system. A 2020 study by Uchoa and Caramelli analyzed troponin I levels in 151 patients undergoing pulmonary resection, regardless of the preoperative cardiac risk classification. Approximately 49% of patients showed elevated troponin I (≥ 0.16 ng/ml), and 22 patients (14.6%) died within one year. Multivariate analysis showed that an increase in troponin I on the first postoperative day was associated with a 12-fold increased risk of death within 1 year (HR 12.02, 95% CI: 1.82–79.5; $p = 0.01$). Although most patients were classified as low-risk for cardiovascular events, elevated troponin I levels were observed in nearly half of the study participants, similar to those observed in other high-risk studies, such as those involving vascular and emergency surgery. This increase in troponin levels can be caused by direct trauma to cardiomyocytes due to thoracic manipulation, resulting in secondary cell injury without immediate ischemic complications. However, there is a possibility that other mechanisms have also been reported to contribute to perioperative myocardial injury; therefore, the interpretation of elevated troponin levels needs to be done carefully (Uchoa & Caramelli, 2020).

A meta-analysis by Smilowitz et al. of 169 studies reported postoperative *cardiac biomarker* outcomes from 530,867 noncardiac surgeries. Data analysis was performed using quantitative analysis of meta-analysis methods for incidence, management, and outcome, as well as qualitative synthesis of the literature to determine the preoperative factors and pathogenesis of MINS. The incidence of MINS was 17.9%, and the confidence interval (IK) was 95%, 16.2–19.6%. Patients with MINS are older, more often male, and more likely to have known cardiovascular risk factors and coronary artery disease than those without MINS. Postoperative mortality was higher in patients with MINS compared to those without MINS, both in hospital (8.1%, 95% CI, 4.4–12.7% vs 0.4%, 95% CI, 0.2–0.7%; relative risk 8.3, 95% CI, 4.2–16.6, $P < 0.001$) and at 1 year postoperative (20.6%, 95% CI, 15.9–25.7% vs 5.1%, 95% CI, 3.2–7.4%; relative risk 4.1, 95% CI, 3.0–5.6, $P < 0.001$). The results showed that troponin T and I levels increased postoperatively in 24.7% and 20.1% of all operations, respectively. An increase in troponin levels is considered a criterion for postoperative myocardial infarction, and many factors influence its incidence. Some intraoperative factors that can affect postoperative troponin elevation include pulse rate, blood pressure, MAP, and vasopressor use (Smilowitz et al., 2019). Other non-ischemic events in thoracotomy surgery, such as severe anemia, hypotension, prolonged tachyarrhythmia, chronic kidney disease, and hypoxemia with respiratory failure, can also cause myocardial injury. These conditions contribute to an imbalance between the myocardial oxygen supply and demand.

In this study, hemoglobin levels and bleeding volumes were associated with elevated troponin levels. These results are similar to those reported by Nandate et al., who evaluated postoperative troponin levels in 320 patients who underwent thoracotomy. High-sensitivity cardiac serum troponin I (hs cTnI) concentrations were measured twice, immediately after arrival in the intensive care unit and on the following day. Hs-cTnI levels increased at 24 h postoperatively in 103 patients (32.2%). In the univariate analysis, intraoperative variables, including the duration of unilateral ventilation (199.2 min, P = 0.0025) and surgery (210.6 min, P = 0.0012), estimated volume of blood loss (406.7 mL, P = 0.0022), percentage of stored red blood cell (RBC) transfusions (10.7%, P = 0.0059), and percentage of lobectomy or combination of other types of lung resection (88.3%, P = 0.00188). Furthermore, a multivariate analysis with three independent risk factors for early progression of concomitant chronic kidney failure was performed: hs cTnI (odds ratio [OR], 3.25), lobectomy or resection (OR, 2.65), and red blood cell transfusion (OR, 3.41). The study showed that an increase in troponin levels was found in 32.2% of patients, and in this population group, OLV, surgical duration, estimated amount of intraoperative bleeding, transfusion, and type of pulmonary resection or lobectomy were factors that significantly influenced the early increase in postoperative troponin levels (Nandate et al., 2023). Intraoperative hemorrhage is often observed in major surgical procedures and causes a decrease in hemoglobin levels, leading to an imbalance in oxygen supply and demand. Park et al. conducted a study on 15,926 noncardiac surgical patients with intraoperative HB and postoperative cardiac troponin measurements and found that (84.2%) had no significant bleeding, while (15.8%) had significant bleeding. After adjustment for inverse probability weighting, the incidence of MINS was higher in the significant bleeding group (35.2% vs. 16.4%; odds ratio 1.58; 95% confidence interval 1.43–1.75; $p < 0.001$). The intraoperative hemoglobin threshold associated with the study's MINS also found that the intraoperative hemoglobin threshold associated with postoperative myocardial infarction was < 9.9 g/dL, which is still below the average hemoglobin level of the study subjects (Park et al., 2021). In this study, the results showed that intraoperative hemorrhage was associated with the incidence of postoperative myocardial infarction, which was associated with impaired oxygen-carrying capacity that occurred along with an increased workload of the heart to maintain adequate systemic circulation. (Park et al., 2021).

Bivariate analysis also showed a relationship between the duration of OLV and increased troponin levels. Tekinbas et al. showed that OLV causes cellular damage, which increases with OLV duration (Tekinbas et al., 2007). This was confirmed by Geze et al. This study involved 45 patients (24 males and 21 females; mean age 54.6 ± 7.7 years; age range 18 to 65 years) in risk groups 1 and 2 according to the American Society of Anesthesiologists, who were scheduled to undergo elective thoracotomy. Patients were randomly divided into three groups: those who underwent thoracotomy without ventilation of one lung (group 1, n = 15), those who underwent thoracotomy with ventilation of one lung (group 2, n = 15), and those who underwent thoracotomy with both lungs that had been ventilated (group 3, n = 15). Blood specimens were collected for albumin, malondialdehyde, and lactate measurements one minute before single-lung ventilation (t0), 30 min after single-lung ventilation (t1), 60 min after single-lung ventilation (t2), and at the 24th hour postoperatively (t3). In Group 1, t0 was defined as the time when the thorax was opened. Statistically significant increases in albumin, malondialdehyde, and lactate levels occurred

in Group 2, along with an increase in the duration of one-lung ventilation ($p < 0.01$), which proved that plasma malondialdehyde levels increased in correlation with OLV duration. Malondialdehyde levels are used as a marker of oxidative stress. In this study, the statistical results for OLV duration indicated that $p < 0.001$ was attributable to the duration of hypoxemia during OLV. Oxidative stress triggered by reperfusion ischemic injury can occur due to hypoperfusion of the unventilated lungs during OLV and reperfusion with reventilation after OLV. This damage was found to depend on OLV duration; the longer the duration of OLV, the greater the hypoxemia and oxidative stress, thereby increasing the risk of ischemic damage, as evidenced by increased levels of troponin (Geze et al., 2019).

Multivariate analysis revealed an influence on PaO2 values and troponin levels. The analysis revealed that among the factors affecting troponin levels, PaO2 had the greatest influence after thoracotomy with OLV. In a single-center retrospective cohort study by Zorilla et al. involving 3,228 patients who underwent lung resection with OLV from 2017 to 2022, vital signs and ventilator arrangements were recorded every minute. Intraoperative hypoxemia was defined as an episode of oxygen desaturation (Spo2 < 90%) for a minimum of 5 min. Demographic and clinical characteristics were included in a graded logistic regression model to select predictors for the risk-score model. All patients included in this cohort underwent elective lung surgery in the lateral decubitus position with *double-lumen ETT* and confirmation of placement by fiberoptic bronchoscopy. The incidence of hypoxemia during OLV was 8.9% (95% confidence interval [CI], 8.0–10.0). Multivariable logistic regression identified nine risk factors with corresponding scores: Preoperative Spo2 < 92% (15 points), hemoglobin < 10 g/dL (6 points), age > 60 years (4 points), male sex (4 points), body mass index > 30 kg/m2 (8 points), diabetes mellitus (4 points), congestive heart failure (7 points), hypertension (3 points), and right-sided surgery (3 points). After correction, it was 0.708 (95% IK, 0.676–0.74). Based on the highest Youden index, the optimal score for predicting intraoperative hypoxemia was 13. The risk of hypoxemia increased from 4.7% in the first quartile of the score (0–13 points) to 32% in the third quartile (27–39 points) and 83.3% in the fourth quartile (> 39 points). At a score of ≥ 20, the model's specificity exceeded 90% and its positive predictive value was 80%. (Zorrilla-Vaca, 2025)

Increased PaO2 levels or hyperoxia can affect myocardial injury, as high PaO2 can induce excessive oxidative stress and increase the production of reactive oxygen species (ROS). ROS can damage myocardial cellular structures, including the cell membrane, mitochondria, and DNA, leading to disturbances in heart contractility. Hyperoxia can also cause vasoconstriction of the coronary blood vessels, reducing the blood flow necessary to maintain the oxygen supply to the myocardium, further worsening myocardial perfusion. However, evidence on the effects of hyperoxia, especially in patients undergoing thoracic surgery, is limited, and there are currently no guidelines available on recommendations for adequate oxygen therapy in patients undergoing thoracic surgery. In the context of medical procedures such as OLV, optimal PaO_2 regulation is essential to prevent the side effects of excessive oxygen levels that can damage myocardial tissue (Ju et al., 2022).

An increase in troponin levels during OLV use can be associated with myocardial infarction type 2, an ischemic injury to the myocardium caused by a mismatch between the supply and oxygen demand. This

condition is associated with changes in *oxygen delivery* affected by OLV. During OLV, only one lung is ventilated, while both lungs receive blood perfusion, resulting in intrapulmonary shunts and perfusion-ventilation imbalances. This condition lowers arterial oxygen levels and oxygen saturation, resulting in systemic hypoxemia (Sha et al., 2025; Shum et al., 2023). Compensation from the body occurs through hypoxic pulmonary vasoconstriction, which diverts blood flow to the ventilated lungs; however, this response is often disrupted by the effects of inhalational anesthesia, patient position, hypotension, high airway pressure, and hypoxemia. Decreased blood oxygenation during OLV leads to a decrease in DO_2 to tissues, including the myocardium, which relies heavily on the oxygen supply to maintain contractility. An imbalance between myocardial oxygen supply and demand increases the risk of ischemia and myocardial infarction, characterized by the release of troponin into circulation (Sha et al., 2025; Shum et al., 2023).

The results of this study show that the use of OLV in thoracic surgery provides significant clinical benefits, both perioperative and physiological. Operatively, OLV facilitates surgical side collapse, increasing exposure and workspace for surgeons without excessive manipulation of the intrathoracic organs. From a perioperative perspective, OLV allows for better ventilation and oxygenation control, thus helping to maintain hemodynamic stability. Blood gas analysis during OLV also provides objective guidance for regulating FiO_2, tidal volume, and airway pressure to prevent hypoxemia and hypercapnia. In this study, the use of OLV with a ventilation setting of 50% air: 50% oxygen, tidal volume of 5–6 mL/kgBW, and a respiratory rate of 12 times/min resulted in a stable perioperative condition, with improvements in AGD and hemodynamic parameters, which supported the safety of the procedure. Overall, OLVs provide broad clinical benefits by minimizing respiratory complications, maintaining tissue perfusion and oxygenation, and supporting better cardiovascular outcomes in patients undergoing thoracic surgery.

This study has several limitations. First, this study evaluated postoperative troponin T and I levels at a single time point, which does not rule out the possibility of a longer-term effect of OLV on troponin levels. Second, troponin levels were measured with a research reagent, so only pre- and postoperative changes were known, without the normal range. Third, this study used troponin levels as the dependent variable; therefore, further research should consider other heart disease parameters, such as ECG and echocardiography, to strengthen the results of this study. These four studies evaluated only preoperative and postoperative parameters, and no measurements were taken during the operation; therefore, it was not possible to determine whether the parameter changes occurred during the operation or after the operation.

Conclusion

It is proven that there is a relationship between the One Lung Ventilation (OLV) technique and Troponin T and I levels in Thoracic Surgery Procedures, with PaO2 values proven to be related to troponin T and troponin I levels after thoracic surgery procedures in patients who applied *one lung ventilation* (OLV) at Prof. Dr. Margono Soekarjo Purwokerto Hospital.

Declarations

Conflict of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contribution Statement

MM Rudi Prihatno (MR), Rania AH (RAH), and Iwan DC (ID) contributed to the study conception and design. Material preparation, data collection and analysis were performed by Rania AH (RAH) and MM Rudi Prihatno (MR). The first draft of the manuscript was written by MR and all authors commented on previous versions of the manuscript.

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Author Contribution

MRP and RAH designed the subject; MRP and RAH participated in data statistics and analysis and article writing; RAH and ID collected the data; MRP and RAH performed the data analysis; MRP, ID , and RAH participated in the revision and discussion of the article. All authors have read and approved the final version of the manuscript

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Data Availability

The data save in https://data.mendeley.com/datasets/xp7hc44dzz/1 : authorship agreement, table data, clinical trials, information and readiness sheet.

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