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High-Sensitivity Cardiac Troponin Levels Difference in Before and After Ear and Nose Surgery with Controlled Hypotension Technique

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ABSTRACT

Background: Anesthesia with controlled hypotension or intraoperative hypotension (IOH) is a technique in which arterial blood pressure is lowered in a deliberate and predictable situation, aimed at facilitating surgery and reducing bleeding and transfusion requirements. However, this surgical technique is not without complications. Detection of MI depends on biomarker fluctuations. Cardiac troponin is the biomarker of choice for diagnosing myocardial damage and MI. Research on the relationship between hs-cTn levels and the incidence of postoperative myocardial infarction and controlled hypotension has never been done before, especially in troponin I and in ear and nose surgery. Methods: This study is an observational analytical study with a cross-sectional method to assess the incidence of myocardial infarction in patients undergoing elective tympanoplasty, mastoidectomy, septoplasty, rhinoplasty, and functional endoscopic sinus surgery (FESS). Results: There were 38 study subjects with 57.6% (20 subjects) being male and 47.4% (18 subjects) being female. The mean preoperative hs-cTn level was 33.87 ± 11.78 pg/mL, while the postoperative hs-cTn level was 43.46 ± 12.21. The mean change in hs-cTn levels between preoperative and postoperative was +9.59 ± 6.62 with a median of 7.78 (1.04-28.27) with a significant difference of $p<0.001$ and a high correlation ($r=0.848$). Conclusion: From our study, it can be concluded that the difference in hs-cTn levels between before and after ear and nose surgery with controlled hypotension technique is significantly different.

KEYWORDS: C/T Ratio, Transfusion Index, Transfusion Percentage

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INTRODUCTION

Anesthesia with controlled hypotension or referred to as intraoperative hypotension (IOH) is a technique in which arterial blood pressure is lowered in a deliberate and predictable situation, aiming to facilitate surgery and reduce bleeding as well as transfusion requirements. Generally, for healthy patients, controlled hypotension is defined as a decrease in systolic blood pressure to 80-90 mmHg or a decrease in mean arterial pressure (MAP) to 50-65 mmHg or a 30% decrease from baseline MAP [1]. However, this surgical technique is not without complications.

The perfusion pressure required to maintain stable blood flow in several different organs varies greatly with a very wide range, so various durations of IOH can cause different outcomes from each organ. From a clinical perspective, the relationship between the degree or duration of IOH and acute kidney injury (AKI), myocardial injury or mortality is still unclear in non-cardiac surgery. A meta-analysis showed that IOH itself significantly increases the risk of AKI, myocardial injury and mortality. Unfortunately, however, the degree of hypotension was not recorded [2,3].

Cardiac complications in the perioperative period occur more frequently in elderly populations [4], this occurs due to an imbalance between oxygen supply and demand, which results in myocardial ischemia. In cardiovascular events in non-cardiac surgery evaluated by cohort (VISION), myocardial injury was diagnosed by the presence of a peak fourth-generation Cardiac Troponin-T (TnT) at 0.03ng ml-1 or more, caused by myocardial ischemia. Mortality after 30 days in patients who experienced myocardial injury after non-cardiac surgery was at 9.8%. In previous studies, perioperative myocardial infarction (MI) was associated with 15-25% mortality. Determining the presence of perioperative MI is very difficult due to the absence of myocardial ischemic symptoms, most perioperative MI appears 24-48 hours after surgery, when patients receive analgesia and sedatives, this limits the ability to recognize and communicate the symptoms that arise. Signs that appear after surgery such as hypotension, tachycardia, shortness of breath or nausea, are not specific to myocardial ischemia and can be misinterpreted as atelectasis, pneumonia, hypovolemia or drug side effects [5].

MI detection depends on biomarker fluctuations. Cardiac troponin is the biomarker of choice for diagnosing myocardial damage and MI [6]. The American Heart Association/American College of Cardiology (AHA/ACC) guidelines provide recommendations on high-sensitivity cardiac troponin (hs-cTn) as the biomarker of choice for establishing the presence of myocardial injury, the use of clinical decision pathways (CDPs) and uniqueness in patients and other patients [5,7].

Research on the relationship between hs-cTn levels and the incidence of postoperative myocardial infarction and controlled hypotension has never been conducted before, especially on troponin I and in ear and nose surgery. Therefore, researchers will attempt to study the relationship between hs-cTn levels and the incidence of myocardial infarction through examination of hs-cTn biomarkers in patients undergoing ear and nose surgery performed with controlled hypotension at Dr. Soetomo Regional General Hospital.

METHOD

Research Design

This research is an observational analytical study with a cross-sectional method to assess the incidence of myocardial infarction in patients undergoing ear and nose surgery performed with controlled hypotension.

Research Location and Time

This research will be conducted at the Integrated Surgical Center Building (GBPT) Dr. Soetomo Regional General Hospital.

Research Population and Sample

Patients undergoing elective tympanoplasty, mastoidectomy, septoplasty, rhinoplasty, and functional endoscopic sinus surgery (FESS) operations at the Integrated Surgical Center Building (GBPT) Dr. Soetomo Regional General Hospital. The research sample consists of patients undergoing elective tympanoplasty, mastoidectomy, septoplasty, rhinoplasty, and functional endoscopic sinus surgery (FESS) operations at the Integrated Surgical Center Building (GBPT) Dr. Soetomo Regional General Hospital who meet the inclusion criteria and exclusion criteria.

Determination of sample size for the difference between two quantitative data with quantitative data results using the formula.[8] Previous research linking the increase in hs-cTn between before and after non-cardiac surgery had a mean difference d = 3 ng/mL and a standard deviation difference σ = 4.364 ng/mL [9]. The total sample was rounded to 38 subjects.

Inclusion criteria

1) Age 18-60 years.
2) Patients who will undergo elective tympanoplasty, mastoidectomy, septoplasty, rhinoplasty, and functional endoscopic sinus surgery (FESS) operations at the Integrated Surgical Center Building (GBPT) Dr. Soetomo Regional General Hospital Surabaya with general anesthesia.
3) Patients with American Society of Anesthesiologists (ASA) physical status examination results I-II.
4) Patient or family willing to sign the informed consent form to participate in the research.

Exclusion criteria

1) Hypertension.
2) History of heart and coronary disease.
3) History of cerebrovascular disease
4) History of blood hemodialysis
5) Infection or Sepsis.
6) Use of anticoagulant drugs.
7) Patients with severe visual or hearing impairment.
8) Patients who cannot read and write.
9) Patients who have high preoperative hs-cTnT values.

Drop out criteria

1) Patient or patient's family cannot be contacted further for research purposes.
2) Patient experiences a severe decline in condition so that laboratory examination cannot be performed.
3) Patient is unwilling to undergo laboratory examination
4) Research data is incomplete.

Research Data Collection Method

Patients scheduled to undergo elective tympanoplasty, mastoidectomy, septoplasty, rhinoplasty, and functional endoscopic sinus surgery (FESS) operations at the Integrated Surgical Center Building (GBPT) Dr. Soetomo Regional General Hospital Surabaya with general anesthesia who meet the inclusion criteria are taken as samples. At 1 hour before surgery, hs-cTnT laboratory examination is performed. The hs-cTnT laboratory examination is repeated at 2 hours after surgery.

Data Processing and Analysis Techniques

Data that has been collected will be recorded and tabulated. Data processing in this study uses SPSS Software (SPSS Inc., Chicago, IL, USA). All demographic characteristic data and perioperative monitoring will be summarized using descriptive statistics. The statistical tests used in this study are as follows:

1) Normality Test

Aims to test the distribution of the data produced. Tests are performed on all data to be presented including demographic characteristics, monitoring, and hs-cTnT level examination results. Normality testing uses the Kolmogorov-Smirnov test if the research data numbers 50 or more. The Shapiro-Wilk test is used if the research data numbers less than 50. If the data is normally distributed, data will be presented in mean and standard deviation. If the data is not normally distributed, data will be presented in median and range.

2) Paired Difference Test

Aims to differentiate the value of hs-cTnT biomarkers at 1 hour before surgery with 2 hours after surgery. If the data is normally distributed, it is tested with Paired T Test, if not normal with Wilcoxon Signed Rank Test.

RESULT

This research is a descriptive retrospective study by recording blood order filling data before surgery both for on-hand stock and GSH for elective surgery at the Integrated Central Surgery Building of RSUD Dr. Soetomo. The research sample was all patients who underwent elective surgery at the Integrated Central Surgery Building of RSUD Dr. Soetomo from January 2023 to December 2023 who placed blood orders. This research aims to assess the effectiveness of blood request and use during surgery in elective Central Surgery patients at RSUD Dr. Soetomo.

This study used 5411 blood order filling data before surgery with 2428 patients with blood requests. The data that had been obtained were extracted and analyzed to determine the effectiveness of blood request and use during surgery in elective Central Surgery patients at RSUD Dr. Soetomo.

Research Sample Characteristics

Demographic Characteristics

Table 1: Demographic characteristics of research subjects

Demographic Characteristics	Results (n=38)	p-value*
Age (18-55 years)		
Gender		
Male	20 (52.6%)	
Female	18 (47.4%)	
Education		
Elementary (SD)	2 (5.3%)	
High School (SMA)	23 (60.5%)	
Bachelor's (S-1)	13 (34.2%)	
Body weight (kg)	57.68 ± 11.05	0.053
Height (cm)	161.66 ± 8.34	0.445
BMI (kg/m²)	22.04 ± 3.60	0.421
Type of Operation		
CWD	10 (26.3%)	
CWU	12 (31.6%)	
FESS	11 (28.9%)	
Septoplasty	5 (13.2%)	
ASA PS		
I	16 (42.1%)	
II	22 (57.9%)	
Anesthesia duration (minutes)	242.50 (125-295)	<0.001
Operation duration (minutes)	217.5 (105-240)	<0.001

SD: elementary school; SMA: high school; S-1: bachelor's degree; CWD: canal wall down; CWU: canal wall up; FESS: functional endoscopic sinus surgery; BMI: body mass index; PS ASA: physical score American Society of Anesthesiologists
p>0.05 indicates normally distributed data

In this study, there were 38 research subjects with 20 males and 18 females. Demographic characteristic data in the form of age, gender, education, body weight (BW), height (H), body mass index (BMI), type of operation, physical score American Society of Anesthesiologists (PS ASA), anesthesia duration, and operation duration were collected and tabulated. Of all demographic characteristic data, BW, H, BMI data were normally distributed ($p>0.05$), so they were presented in mean ± standard deviation. Meanwhile, age, anesthesia duration, and operation duration data were presented in median and range (minimum-maximum) because the data were not normally distributed ($p<0.05$) (Table 1).

Monitoring data from each patient in the form of systolic, diastolic, mean arterial pressure (MAP), pulse, bispectral index (BIS), and end-tidal carbondioxide (EtCO2) were collected and tabulated. Of all monitoring parameters of research subjects, systolic, diastolic, MAP, pulse, and BIS data were normally distributed ($p>0.05$). Meanwhile, EtCO2 was not normally distributed ($p<0.05$). Therefore, systolic, diastolic, MAP, pulse, and BIS data were presented in the form of mean and standard deviation, while EtCO2 was presented with median, minimum, and maximum (Table 2).

Table 2: Operative monitoring data of research subjects

Monitoring Parameter	Results (n=38)	p-value*
Systolic (mmHg)	98.85 ± 3.55	0.817
Diastolic (mmHg)	58.62 ± 1.76	0.364
MAP (mmHg)	72.25 ± 1.94	0.126
Pulse (bpm)	74.18 ± 5.75	0.217
BIS	54.22 ± 3.41	0.117
EtCO2 (mmHg)	36.44 (30.38-39.43)	<0.001

MAP: mean arterial pressure; BIS: bispectral index; EtCO2: end-tidal carbondioxide
p>0.05 indicates normally distributed data

Changes in High Sensitivity Cardiac Troponin Levels in Ear and Nose Surgery with Controlled Hypotension Technique

The normality test results using Shapiro-Wilk on high sensitivity cardiac troponin (hs-cTn) level data before and after surgery showed p-values of 0.904 and 0.886, which means both data are normally distributed, so the data are presented in the form of mean and standard deviation (Table 3).

Table 3: Preoperative and postoperative hs-cTn level data

Parameter	Results (pg/mL)	p-value*
Preoperative hs-cTn level (n=38)	33.87 ± 11.78	0.904
Postoperative hs-cTn level (n=38)	43.46 ± 12.21	0.886

hs-cTn: high sensitivity cardiac troponin
p>0.05 indicates normally distributed data

Using the paired T test, the difference between hs-cTn levels before surgery and after surgery showed a p-value <0.001, which means that the difference is significant. The correlation between the two differences showed 0.848, which indicates a high significance of that difference with a mean change of +9.59 ± 6.62 pg/mL (Table 4).

Table 4: Difference in hs-cTn levels between preoperative and postoperative

Parameter	Change	p-value*
Preoperative vs. postoperative hs-cTn level (pg/mL)	+9.59 ± 6.62	<0.001

hs-cTn: high sensitivity cardiac troponin
p<0.05 indicates significant difference

Figure 1 shows the picture of hs-cTn level changes in all research subjects. All research subjects experienced an increase in hs-cTn levels after ear and nose surgery compared to before ear and nose surgery with controlled hypotension technique.

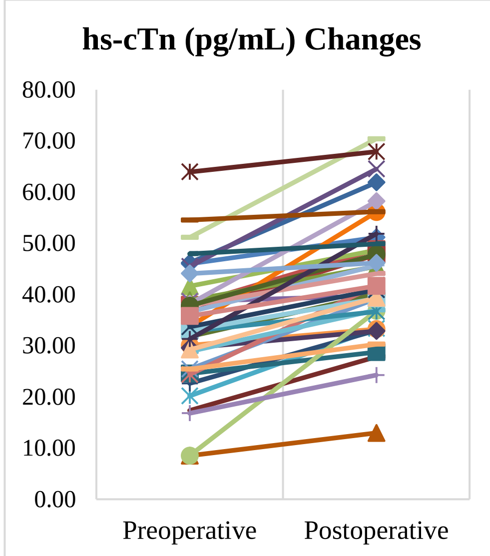

Figure 1: Picture of hs-cTn level changes between preoperative and postoperative for each research subject.

DISCUSSION

Demographic Characteristics

High-sensitivity cardiac troponin T (hs-cTnT) is widely used to diagnose acute myocardial infarction, but its accuracy is influenced by age. Research has shown that the conventional cutoff value of 0.014 ng/mL provides low specificity, especially in elderly patients [10]. The specificity and positive predictive value of high-sensitivity cardiac troponin I (hs-cTnI) for myocardial infarction decreases with increasing age [11]. In patients aged 75 years and above without NSTEMI, 72.2% had hs-cTnT concentrations above the 99th percentile of the healthy reference population [12]. The magnitude of cardiac troponin release in myocardial infarction reflects the magnitude of ischemic injury and is a strong predictor of poor prognosis, with increased troponin release implying more severe prognostic consequences in older patients [13]. In this study, the oldest age of research subjects was 55 years.

Studies show that the use of sex-specific diagnostic thresholds for hs-cTnI can significantly improve the diagnosis of myocardial infarction in women, potentially doubling the rate [14]. The prognostic value of hs-cTnI for cardiovascular death is stronger in women than in men [15]. These gender differences are very prominent for myocardial infarction, but less so for heart failure [16]. Interestingly, men generally have higher hs-cTnI concentrations than women, which may reflect subtle disturbances in cardiovascular status [15]. These findings highlight the importance of considering sex-specific thresholds in hs-cTnI tests for better diagnosis and risk stratification in acute coronary syndromes [17]. In our study, males and females numbered 20 (52.6%) and 18 (47.4%), which can represent each gender.

Recent studies have shown a strong relationship between obesity and subclinical myocardial injury, measured by hs-cTnT levels. Higher body mass index (BMI) is independently associated with increased hs-cTnT concentrations, with severe obesity significantly increasing the risk of high hs-cTnT levels [18,19]. This relationship persists even when accounting for coronary heart disease and is observed across various age groups and genders [16]. The relationship between BMI and hs-cTnT appears to be stronger in individuals with higher BMI categories [20]. Furthermore, obesity and elevated hs-cTnT levels independently and synergistically increase the risk of heart failure [18]. In our study, the mean BMI was 22.04 ± 3.60, which is still in the normal BMI category.

Difference in High-sensitivity Cardiac Troponin Results between Preoperative and Postoperative in Ear and Nose Surgery with Controlled Hypotension Technique

In the context of surgery, the controlled hypotension technique is a technique used to minimize blood loss and improve surgical conditions. However, this practice raises concerns regarding its impact on high-sensitivity cardiac troponin (hs-cTn) levels, which is an important biomarker for myocardial injury. Elevated hs-cTn levels during and after surgery can indicate myocardial damage, particularly in patients undergoing non-cardiac surgery where intraoperative hypotension is common.

Research has shown that hypotensive states during surgery can lead to increased hs-cTn levels, which serve as indicators of myocardial stress and injury [21,22]. A systematic review showed that intraoperative hypotension is a significant risk factor for myocardial injury after non-cardiac surgery, with increased troponin levels as a consequence [22]. Other research also shows that patients with intraoperative hypotension have a higher incidence of postoperative complications, including acute kidney injury and myocardial infarction, which correlate with increased hs-cTn levels [23]. Moreover, in patients who already have preoperative heart abnormalities, which can increase the likelihood of myocardial infarction occurring in these patients [24].

The use of controlled hypotension technique has been proven to effectively manage intraoperative blood pressure while minimizing blood loss [25]. However, the relationship between this technique and hs-cTn levels is still complex. Although controlled hypotension can facilitate surgical procedures, it can inadvertently cause myocardial ischemia, especially in patients with pre-existing cardiovascular conditions [26]. This is confirmed by findings showing a direct correlation between the level of intraoperative hypotension and increased post-surgical hs-cTn levels [27].

In our study, the significant and strongly correlated increase in hs-cTn in nose and ear surgery with controlled hypotension technique (Table 4) may indicate that the controlled hypotension technique can cause myocardial infarction. Even in Figure 1, it shows that all research subjects experienced an increase in hs-cTn. However, there are several things that need to be underlined, namely the sensitivity of hs-cTn level examination which is more sensitive than routine troponin examination.

The evolution of cardiac troponin assays from conventional testing to hs-cTn has significantly impacted the diagnostic landscape for acute myocardial infarction and other cardiac conditions. The main difference between these two types of assays lies in their sensitivity and ability to detect lower troponin concentrations, which is crucial for early diagnosis and risk stratification.

High-sensitivity troponin assays are designed to detect troponin levels 5 to 10 times lower than what can be detected by conventional assays. These hs-cTn assays have enhanced sensitivity to measure cardiac troponin concentrations in more than 50% of normal individuals, which is a significant improvement compared to conventional assays that typically measure troponin levels in only a small fraction of the population [28,29].

These assays have been proven to improve early diagnosis of acute myocardial infarction, especially in populations such as the elderly, where conventional assays may fail to effectively identify myocardial injury [30]. The hs-cTn assay is associated with better risk stratification in patients experiencing acute dyspnea and chest pain, thus allowing for more tailored treatment approaches [31]. However, the increased sensitivity of hs-cTn assays also poses challenges. Detection of low troponin levels in patients without AMI can lead to over-diagnosis and unnecessary interventions, thus complicating clinical decision-making [28,32]. Scott et al. (2008) also noted that troponin I elevation can occur in various non-cardiac contexts, indicating that not all elevations indicate irreversible myocardial damage [33].

Recent research highlights that not all elevations of high-sensitivity cardiac troponin T (hs-cTnT) indicate irreversible myocardial damage. Hannibal (2013) emphasizes that troponin elevation occurs in various acute and chronic conditions, not just acute coronary syndromes [34]. Vafaie et al. (2014) also provide a comprehensive list of causes of troponin elevation, including ischemic and non-ischemic myocardial injury [35]. Duma et al. (2018) highlight that hs-cTn elevation can occur in healthy individuals undergoing non-cardiac surgery, indicating that such elevations may not always correlate with myocardial damage but rather with temporary physiological responses [36]. They note that high-sensitivity assays increase the detection of true positive results in non-ST elevation myocardial infarction and other conditions. These studies collectively show that although troponin is a valuable biomarker for myocardial damage, its interpretation requires careful consideration of clinical context and potential non-ischemic causes of elevation.

This indicates that although troponin levels may increase during hypotensive episodes, it does not automatically imply that myocardial infarction has occurred. Therefore, although hs-cTn testing represents a significant advance in cardiac biomarker testing, its interpretation must be contextualized within the broader clinical picture to avoid misdiagnosis.

CONCLUSION

Based on the results of the study, several conclusions can be drawn. Normal hs-cTnT levels were observed in patients before undergoing ear and nose surgery using the controlled hypotension technique. After surgery, hs-cTnT levels showed an increase but remained within the normal range. The difference in hs-cTnT levels before and after surgery increased significantly. hs-cTnT levels also serve as an early indicator for detecting acute myocardial infarction. Overall, the controlled hypotension technique is considered safe for use in ENT surgical procedures.

From these findings, several suggestions can be proposed. Further research is encouraged to include additional measurement parameters related to myocardial infarction beyond hs-cTnT. This study may be used as a reference for subsequent research by incorporating other analytical indicators. The main limitations of this study include the duration of the research and the sample size.

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