EVALUATING THE INTRAOPERATIVE CHANGES IN SEVERAL HEMODYNAMIC PARAMETERS USING THE USCOM METHOD IN SEVERE BURN PATIENTS UNDERGOING BURN NECROTOMY, SKIN GRAFTING

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ABSTRACT

***Objectiv**e: To evaluate the intraoperative changes in some hemodynamic parameters by the USCOM method in severe burn patients undergoing burn necrotomy, and skin grafting.*

***Subjects and methods:** 30 severe burn patients, aged 16 - 60 years old, treated at the ICU, National Burn Hospital, were scheduled for necrosis and skin grafting from May 2023 to December 2023. Cross-sectional, clinical descriptive study.*

***Results:** CO and CI values at all study times were within normal limits (3.5-8 l/min and 2.4-4.2 l/min/m^2). CO and CI were highest at the time of pre-medication (6.93 and 4.24) and lowest at the time of skin grafting (5.87 and 3.61). SVR values at all times were within normal limits (800 - 1600 d.s.cm-5). SVR was highest at the time the patient was awake (1278.33) and lowest at the time immediately after induction of anesthesia (976.93). SVRI values 3 times after induction of anesthesia, before necrotomy, and at the time of necrotomy were lower than normal values (1800 - 3200 d.s.cm-5.m^2). SVI at the remaining time points was within normal limits. SV values at all times were within normal ranges (50-110 cm^3). SVI values at most times were smaller than normal values (35 - 65 ml/m^2), except for at the time of necrotomy (35.03). SVV values at all times were higher than normal (< 20%).*

***Conclusion:** Stroke volume variation (SVV) parameters at all study times were higher than normal values corresponding to the age range. The stroke volume index parameter SVI at most times was lower than the normal value, and SVRI at all times was not higher than the normal value. However, the parameters cardiac output (CO), cardiac index (CI), stroke volume (SV), and systemic vascular resistance (SVR) were all within the range of normal values corresponding to the age range at the research time points.*

***Keywords**: USCOM, anesthesia, necrotomy, skin grafting, burn*

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1. INTRODUCTION

Intraoperative blood loss can bring about hemodynamic disorders and affect the function of organs, especially the heart, kidney, and brain; acid-base imbalance; hypothermia; coagulation disorder; and even death. Burn necrotomy and skin grafting for treating severe burn patients usually result in much blood loss. According to a statistic, for every 1% of burn necrosis removed, the amount of blood loss is 6.4 ± 5% of the total blood in the body [1]. Therefore, intraoperative hemodynamic monitoring in burn necrotomy and skin grafting in severe burn patients is essential in order to early detect and timely correct hemodynamic disorders.

In recent years, the Ultrasound Cardiac Output Monitoring (USCOM) method has allowed for the monitoring of hemodynamics in a non-invasive manner. Studies have shown that the USCOM method has the same reliability as invasive methods such as PiCCO in monitoring hemodynamic parameters such as cardiac index (CI), stroke volume index (SVI), stroke volume variation (SVV), and systemic vascular resistance index (SVRI) [2]. This method has been applied to monitoring hemodynamic parameters in severe burn patients in the stages of burn shock and septic shock [3]. However, this method has not been systemically applied for hemodynamic monitoring in burn necrotomy and skin grafting surgery in severe burn patients. Consequently, we conducted this study in order to evaluate the changes in some hemodynamic parameters by using USCOM in burn necrotomy and skin grafting surgery in severe burn patients.

2. SUBJECTS AND METHODS

2.1. Subjects

* Subjects: 30 severe burn patients, treated in the ICU, Le Huu Trac National Burn Hospital, from May 2023 to December 2023.

* Inclusion criteria: Aged 16 - 60 years old, burn area 30 - 60%, indicated for burn necrotomy: 5 - 15% total body surface area (TBSA), ASA II, III.

* Exclusion criteria: Patients with concomitant traumas, myocardial diseases (valve diseases, heart failure with NIHA III, IV, arrhythmia).

2.2 Methods

The clinical descriptive cross-sectional study.

2.2.1. Medications and materials

Midazolam ampoule 5mg/ml (Rotexmedica - Germany), Ketamine vial 500mg/10ml (Rotexmidica- Germany), Propofol ampoule 200mg/20ml (Fresenius Kabi-Austria), Fentanyl ampoule 500mcg/10ml (Rotexmidica - Germany). Medications for repiratory, circulatory resuscitation, and fluids.

USCOM machine version 2 (USCOM company, 2009, Australia) with Dopper probe 2.2MHz, Life Scope Nihon Kohden (Japan), able to monitor heart rate, ECG, invasive blood pressure, and SpO_2.

2.2.2. Procedure

- At the ICU, Le Huu Trac National Burn Hospital, the patient was examined one day before surgery and guided for preoperative fasting.

- At the Operating Room

- The patients were monitored for heart rate, invasive blood pressure, respiratory rate, and SpO_2.

- Given an IV infusion with Ringerlactat of 10ml/kg

- Anesthesia procedure

+ Premedication: Midazolam 0.05mg/kg

+ Induction: Ketamin 1mg/kg, Fentanyl 3µg/kg, and Propofol 3mg/kg. When the patient lost consciousness, the mouth muscle relaxed, the LMA was inserted.

+ Maintenance: Using volume control ventilation (VCV) mode with Vt = 8ml/kg ideal body weight, respiratory rate 14-16 breaths/min, and an I: E ratio of 1:2 to maintain an $EtCO_2$ of 30 - 40mmHg. Propofol 1mg/kg/h was infused via a syringe pump; the dose of 0.2 mg/kg/h propofol was adjusted each time and an additional dose of Fentanyl 1 - 2µg/kg/time was given based on the patient's PRST (systolic blood pressure, heart rate, sweating, tear) score.

- Vital signs were monitored every 5 minutes until the surgery was completed.

- At the Recovery Area.

- The LMA was removed when the patient met the criteria.

- The patient was transferred to the ward when the Aldret score was ≥ 9. Postoperative multimodal analgesia based on the ICU's procedure.

2.2.3. Collected parameters

- Patient demographics: Age, gender, height, weight, necrotomy area, skin grafting area.

- Medication dosage of midazolam, ketamin, propofol, and fentanyl; volume of fluids; blood given intraoperatively.

- Some hemodynamic parameters measured by USCOM: Cardiac output (CO), cardiac index (CI), stroke volume (SV), stroke volume index (SVI), stroke volume variation (SVV), systemic vascular resistance, and systemic vascular resistance index (SVRI)

2.2.4. Study time points

Data was collected at 7 - time points: T_0 (right after premedication), T_1 (right after induction), T_2 (before necrotomy), T_3 (right at necrotomy), T_4 (necrotomy completed), T_5 (skin grafting completed), and T_6 (patient awake).

2.2.5. Data analysis

The Statistical Package for Social Science 22.0 (SPSS 22.0) software was used for data analysis. Data was expressed as either mean or standard deviation ($\overline{X} \pm SD$) or numbers and percentages.

2.3. Research ethics

This study was approved by the Medical Research Ethics Committee of the Military Medical University according to Decision $N_{0.}$ 42/2023/CNChT-HĐĐĐ dated June 16, 2023.

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3. RESULTS

3.1. Patient's characteristics

Table 3.1. Patient's demographics

Parameters		Min - Max	$\bar{X} \pm SD$
Age (year)		18 - 59	38.16 ± 14.15
Gender (n, %)	Male	25 (83.33%)	
	Female	5 (16.67%)	
Weight (kg)		47 - 78	61.16 ± 8.64
Height (cm)		155 - 180	166 ± 7.84
Necrotomy area (%)		5 - 15	9.00 ± 3.05
Skin grafting area (%)		5 - 15	9.06 ± 2.97
Surgery duration (min)		30 - 85	56.37 ± 12.38
Anesthesia duration (min)		55 - 110	81.31 ± 15.95
Midazolam (mg)		2.5 - 4	3.02 ± 0.45
Ketamin (mg)		50 - 80	60.63 ± 9.28
Propofol (mg)		410 - 1000	620.33 ± 147.23
Fentanyl (µg)		150 - 500	345.66 ± 78.19
Amount of fluids intraoperatively administered (ml)		500 - 1000	700.00 ± 222.05
Amount of blood intraoperatively transfused (ml)		0 - 500	333.33 ± 75.80

Comments: The mean age of the patients was 38 years old. The majority of patients were male (83.33%). The necrotomy area and the skin grafting area were almost equal, and the surgery duration was about 1 hour. The amount of fluid and blood administered intraoperatively was about 333ml and 700ml, respectively. The amount of Midazolam, Ketamin, Propofol, and Fentanyl administered intraoperatively was about 3mg, 60mg, 620mg, and 345µg, respectively.

3.2. Changes in intraoperatively hemodynamic parameters

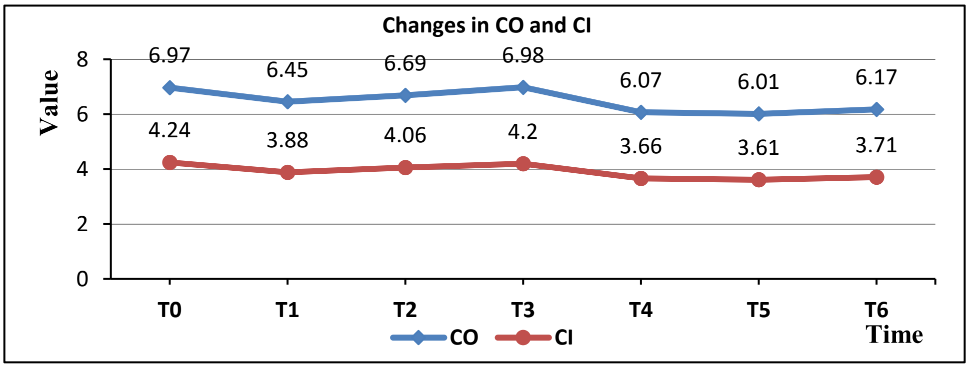

Figure 3.1. Changes in CO and CI at time points

Comments: CO and CI values at all time points were in a normal range (3.5 - 8l/min and 2.4 - 4.2 l/min/m^2). The CO and CI values were highest at the time of premedication (6.93 and 4.24) and lowest at the time of skin grafting (5.87 and 3.61).

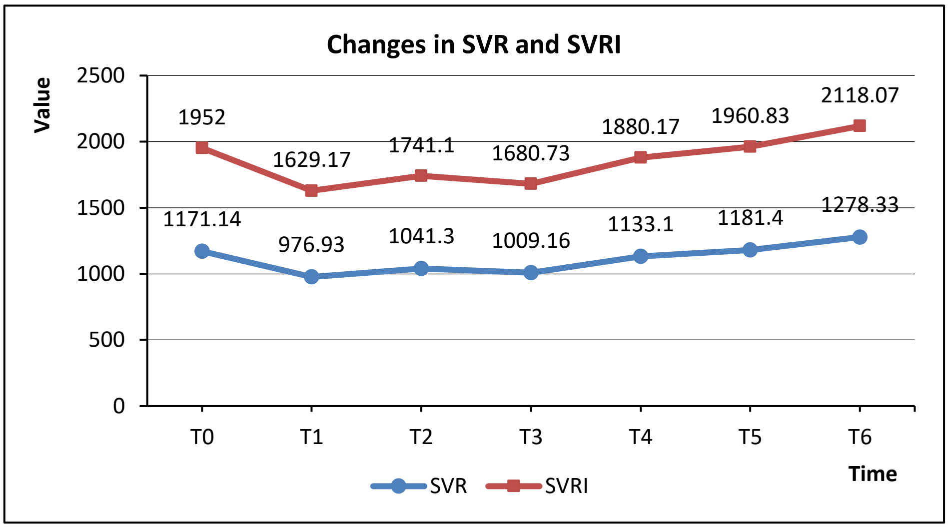

Figure 3.2. Changes in SVR and SVRI at time points

Comments*:* SVR values at all time points were in a normal range (800 - 1600 d.s.cm^{-5}). SVR was highest at T6 (1278.33) and lowest at T1 (976,93). SVRI at T1, T2, and T3 was lower than the normal value (1800 - 3200 d.s.cm^{-5}.m^2). SVRI at the remaining time points was in the normal range.

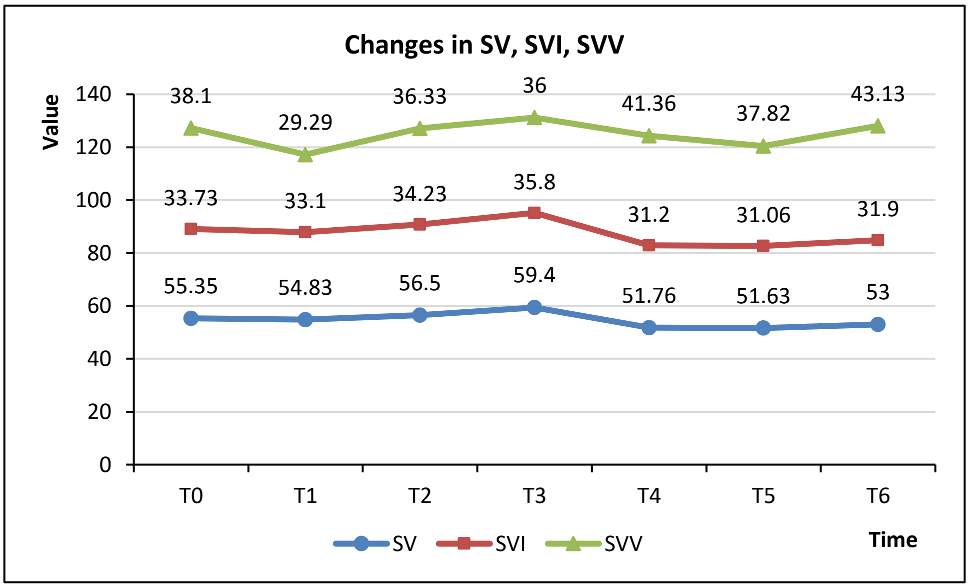

Figure 3.3. Changes in SV, SVI, SVV at time points

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Comments: SV values at all time points were in the normal range (50 - 110cm^3). SVI values at almost all time points were lower than the normal range (35 - 65ml/m^2), except for T3 (35.8). SVV values at all time points were greater than the normal value (< 20%).

4. DISCUSSION

Patients in the study had a mean age of 38 years; the majority were male, with height and weight corresponding to Vietnamese physiological constants (Table 3.1).

Cardiac activity is expressed by cardiac output (CO), which is the volume that the heart pumps out on average per minute and is the result of the coordinated impact of four factors: preload, myocardial contractility, afterload, and heart rate. CO was calculated as stroke volume multiplied by heart rate [3].

CI is calculated as cardiac output divided by the total body skin area. This index does not depend on the patient’s body shape or weight, so it is easy to compare in clinical practice [4].

Low CO and CI are due to low SV, low HR, or both, and vice versa. CO is also valuable in assessing total tissue oxygen delivery, as changes in CO determine the amount of oxygen delivered to the tissues. Low or insufficient CO will lead to tissue hypoxia, cellular hypoxia, and irreversible multiorgan dysfunction [3].

In our study, patients had an average age of 38 years (18 - 59), CO values ranged from 3.5 to 8.0 l/min and CI ranged from 2.8 to 4.2 l/min/m^2. According to the research results in Figure 3.1, we found that CO and CI values at the time of the study were within the normal range.

The CO value in our study was consistent with the CO value at time points in the study of Nguyen Quoc Kinh and colleagues (2016), when these authors evaluated hemodynamic changes measured by USCOM in patients undergoing trauma surgery who were administered crystalloid and colloid fluid before spinal anesthesia [5].

Author Phung Van Dung and colleagues (2017), using USCOM to monitor and evaluate hemodynamics in patients with severe sepsis and septic shock, found that the mean CI value was at a normal level in both groups. In the severe infection group, it was 3.51 ± 1.60 ml/min/m^2, and in the septic shock group, it was 3.47 ± 1.50 ml/min/m^2 [6]. CO and CI values were within normal limits, showing that these hemodynamic parameters in severe burn patients were not affected during the induction and maintenance stages of anesthesia.

Stroke volume (SV) is the volume of blood pumped out of the heart's ventricles with each beat. And can apply to both ventricles of the heart, but usually refers to the left ventricle. This parameter is an important determinant of cardiac output because cardiac output is the product of ejection volume and heart rate. Stroke volume decreases under certain conditions, and in pathological conditions, SV is related to cardiac function. Stroke Volume Index (SVI) is the volume of blood pumped out of the ventricles with each heartbeat per unit of skin area.

SV and SVI are valuable parameters that assist in preload assessment. Their value depends on preload, myocardial contractility, and afterload. Low SV and SVI may be due to low preload (fluid deficiency), weak myocardial contractility, or increased afterload. Conversely, high SV and SVI can be due to fluid overload, increased myocardial contractility, reduced afterload, pain, or anxiety.

In our study, patients had an average age of 38 years (18 - 59), normal values of SV were in the range of 50 - 110cm^3, and SVI was in the range of 35 - 65ml/m^2. According to the results in Figure 3.3, SV values at all times were within normal limits. The SV values in our study were lower than the SV values in the study by author Nguyen Quoc Kinh and colleagues (2016), possibly due to the different nature of the surgery (burn necrotomy and skin grafting versus trauma surgery) and different anesthetic methods (anesthesia versus spinal anesthesia) [5]. SVI values at most times were lower than normal values (Figure 3.3). Author Nguyen Thuy Ngan and colleagues (2020), when using USCOM to monitor hemodynamics in patients with septic shock, showed that SVI at the beginning of the study was lower than normal values (32.5 ± 6.8 ml/m^2) [7].

Stroke volume variation (SVV) was used as an index of ventricular filling. When intrathoracic pressure changes with respiration, the amount of venous blood returning to the heart also changes. Increased intrathoracic pressure will reduce blood flow to the heart and reduce ventricular filling, so SV will also decrease. A volume-deficient patient will have a higher SVV than a volume-adequate patient. SVV is not essentially a reflection of the patient's preload but can assist in assessing the effectiveness of fluid therapy. SVV is believed to have significantly higher sensitivity and specificity than traditional circulatory assessment indices such as heart rate, mean arterial blood pressure, and central venous pressure. In clinical practice, SVV has been widely applied to evaluate fluid response as well as support preload assessment in critically ill patients or those undergoing major surgery.

According to the results in Figure 3.3, SVV values at all study times were higher than normal values (< 20%), indicating a preload deficiency during the surgical period. This situation may occur, possibly due to the use of propofol to anesthetize a surgical procedure with excessive blood loss, thereby causing peripheral vasodilation. Our results were similar to the study of Phung Van Dung and colleagues (2017) in patients with severe infection and septic shock, showing the average value of SVV at the time of hospital admission in two groups of severe infection and septic shock was 27.59 ± 14.16% and 25.33 ± 9.45%, respectively. [6].

Systemic vascular resistance (SVR) is the most accurate afterload assessment parameter. SVR is also known as peripheral vascular resistance, and it depends on the structure of the vascular system, the tone of the arterioles, and the viscosity of the blood. According to the results in Figure 3.2, SVR values at all times were within the normal value range (800 - 1600 d.s.cm^{-5}), the lowest was right after the induction of anesthesia, and the highest was when the patient woke up. This result is also consistent with the study of Nguyen Quoc Kinh and colleagues

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(2016), showing that SVR values at the time of the study in the 0.9% NaCl infusion group were all within normal values, with SVV The lowest was 1300.9 d.s.cm^{-5} and the highest was 1450 d.s.cm^{-5} [5].

According to Figure 3.2, SVRI at all times was not higher than the normal value. Our results are also consistent with the study of Phung Van Dung and colleagues (2017), which showed that the average SVRI values in the severe infection group and the septic shock group were 1789.83 ± 788.83 d.s.cm^{-5}.m^2 and 1575.69 ± 917.14 d.s.cm^{-5}.m^2, respectively [6].

5. CONCLUSION

Through studying 30 cases of burn necrosis and skin grafting, we found that the stroke volume variation (SVV) parameter at all study times was higher than the normal value corresponding to the age range. On the contrary, the SVI stroke volume index at most times was lower than the normal value, and the SVRI at those times was not higher than the normal value. However, the parameters cardiac output (CO), cardiac index (CI), stroke volume (SV), and systemic vascular resistance (SVR) were all within the range of normal values corresponding to the age range at the research time points.

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