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Research Article

Comparison of Body Temperature, Normothermia, and Extubation Times of Patients Heated with Forced Air Warming Method Based on Whether Patients Underwent On-Pump or Off-Pump Coronary Artery Bypass Graft

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ABSTRACT

Aim: This study aimed to compare the body temperature, normothermia, and extubation times of patients heated with forced air warming method based on whether they underwent on-pump or off-pump coronary artery bypass graft.

Method: This quasi-experimental study comprised 109 patients who underwent coronary artery bypass graft operation in the cardiovascular surgery department of a university hospital and a private hospital in Afyonkarahisar. Patients were divided into the following two groups: group 1 comprised 65 patients who underwent on-pump coronary artery bypass graft and group 2 comprised 44 patients who underwent off-pump coronary artery bypass graft. All patients included in the study were heated with forced air warming method. Preoperative and postoperative data were collected using the Patient Identification Form and the Patient Tracking Form, consisting of 16 items in total. Data were analyzed using the Statistical Package for the Social Sciences 18.0 software.

Results: Even though the preoperative body temperature, postoperative first body temperature, second hour body temperature, and extubation time did not exhibit a significant difference depending on the operating method, a significant difference was observed regarding the first, third, fourth, and fifth hour body temperatures and time to reach normothermia based on the operating method ($p<0.05$). Notably, the off-pump group's body temperatures in the first, third, fourth, and fifth hours were higher compared with the on-pump group. Furthermore, the off-pump group reached normothermia (145.22±72.54 minutes) earlier or faster compared with the on-pump group (206.84±89.30 minutes). The body temperatures, extubation times, and normothermia were not observed to exhibit significant differences based on the gender ($p>0.05$). A statistically significant relation was not observed between the patient's body temperature and their age ($p>0.05$). However, a low but positive and significant ($p<0.05$) correlation was observed between the extubation times ($r=0.197$) and age, as well as time to reach normothermia ($r=0.237$) and age.

Conclusion: This study concluded that forced air warming method is an effective technique to minimize the time to regain normothermia among patients who underwent the on- and off-pump coronary artery bypass graft.

Keywords: Coronary artery bypass, extubation, hypothermia

INTRODUCTION

Perioperative hypothermia is defined as the body core temperature below 36°C (Burns, Wojnakowski, Piotrowski & Caraffa, 2009; Hooper et al., 2010). It is a significant complication often encountered after cardiac surgery (Aksu, Kuş, Gürkan, Solak, & Toker, 2014) and can be easily prevented with simple techniques (Güzelay, 2013). Hypothermia results in critical complications, such as prolonged intensive care and hospitalization period, increased need for mechanical ventilation, increased cardiac problems, and increase in mortality (Benson, McMillan & Ong, 2012; Campbell, Alderson, Smith & Warttig, 2012; Hooper et al., 2010). All healthcare personnel are responsible for preventing the hypothermia that may develop as a result of surgery and anesthesia, and these complications endanger patient safety (Berry, Wick & Magons, 2008; Galvao, Marck, Sawada & Clark, 2009). The most significant responsibility in this regard belongs to perioperative nurses whose main objective

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is to plan the interventions required to decrease or prevent complications that might result from surgery and anesthesia by considering patient safety (de Brito Poveda, Clark & Galvao, 2013; Lynch, Dixon & Leary, 2010). Decreasing the time taken to regain normothermia in patients with hypothermia because of interventions performed during the perioperative period will positively affect the success of surgical intervention and the healing process by reducing the frequency of hypothermia-induced complications (Aksu et al., 2014; Kurşun & Dramalı, 2011).

Warm blankets, heating lamps, and pressure air-heating instruments are used to prevent hypothermia, which is a significant risk factor in terms of mortality and morbidity (Campbell, Alderson, Smith, & Warttig, 2012; Hooper et al., 2010). The aim is to increase the body temperature to 36°C to 37.5°C (Aktay-İnal, Ural, Şenol-Çakmak, Arslan, & Polat, 2017; Bilgin, 2017). Previous studies have revealed that patients undergoing cardiopulmonary bypass surgery can reach normothermia by using forced air warming, which is an active heating method (Campbell et al., 2012; Guvakov et al., 2000; Villamaria, Baisden, Hillis, Rajab & Rinaldi, 1997). In addition, the effect of this method of heating on the extubation time has been established (Uysalel, 1997). However, no study could be found that compared the effects of forced air warming method in regaining normothermia and the extubation times between patients who underwent on-pump or off-pump method of cardiac surgery.

Therefore, this study aimed to compare the body temperature, normothermia, and extubation times of patients heated with forced air warming method based on whether they underwent on- or off-pump coronary artery bypass graft (CABG). In addition, the correlation between these variables and gender and age was investigated.

Research Questions

1. Is there a significant difference in terms of the body temperatures, normothermia, and the extubation times of patients based on the operative method-on- or off-pump CABG?
2. Is there a significant difference in terms of the body temperatures, normothermia, and the extubation times of patients based on gender?
3. Is there a significant correlation between variables (body temperatures, normothermia times, extubation times) and age?

METHOD

Study Design

This quasi-experimental study was performed in the cardiovascular surgery department of a university hospital and a private hospital in Afyonkarahisar.

Sample

This study comprised 109 patients (74 men, and 35 women; mean age 64.59±10.12 years, range 36 to 84 years) who underwent cardiac surgery in our clinic between November 2009 and December 2013. Overall, 65 patients (47 men, 18 women; age ranging from 36 to 82 years, with a mean age of 63.64±10.22 years) underwent on-pump CABG and 44 patients (27 men, 17 women; age ranging from 48 to 84 years, with a mean age of 65.98±9.91 years) underwent off-pump CABG. Patients who were above 18 years of age, had undergone CABG by either the on-pump or off-pump method, had chronic stable angina pectoris, had not undergone cardiac surgery before, had undergone elective surgery, not undergone recurrent operation, and had participated voluntarily in the research were included in the study. Patients who were under 18 years of age, had undergone other cardiac surgeries previously, had undergone emergency surgery, had undergone recurrent operations, and who were not willing to voluntarily participate in the research were excluded from the study.

Data Collection

Preoperative and postoperative data were collected using the Patient Identification Form and the Patient Tracking Form.

The Patient Identification Form included 5 questions to determine the demographic characteristics of the patients. The information in the form was filled out during a face-to-face interview on the first day of the patient's admission to the clinic during the preoperative period.

The Patient Tracking Form contained preoperative and postoperative body temperature, operations type, oparation time and extubation time, included 11 questions. The information in the form was filled out during in the operating room the intraoperative period and in the intensive care unit the postoperative period.

Research Process

Patients in the on-pump group were warmed to 37°C at the end of the operation and then trans-

ferred to the intensive care unit without applying any additional heating process. Off-pump group was not heated throughout the surgical procedure. Patients in the off-pump group were transferred to the intensive care after surgery. The initial body temperatures of patients who were taken to the intensive care unit after operation were measured. Patients were covered with the disposable bedspread of the air heating device (PWS 71000, Websinger Gmbh, A-2120 Wolkersdorf). The device was started at 37°C and patients were gradually warmed up to 41°C. Patients were heated to maximum 41°C to avoid causing burns. Patients were heated to provide hemodynamic stability immediately after admission to the intensive care. All patients were heated to reach normothermia. The body temperatures of patients for every hour of the first 5-hour postoperative period was measured using the rectal temperature probe (FMT brand 400 series) until their body temperatures reached 36°C. Additionally, the times at which patients regained normothermia and when the extubation occurred were recorded (Figure 1).

All operations, both off-pump and on-pump, were performed by the same surgical team by using the same surgery technicalities. Median sternotomy was performed in all patients. Hypothermia was set at 28–32°C for the on-pump group. The routine cardiac anesthesia procedure was performed. Patients included in the study were monitored during the initial 24 hours postoperatively. No patient developed any complications during this period.

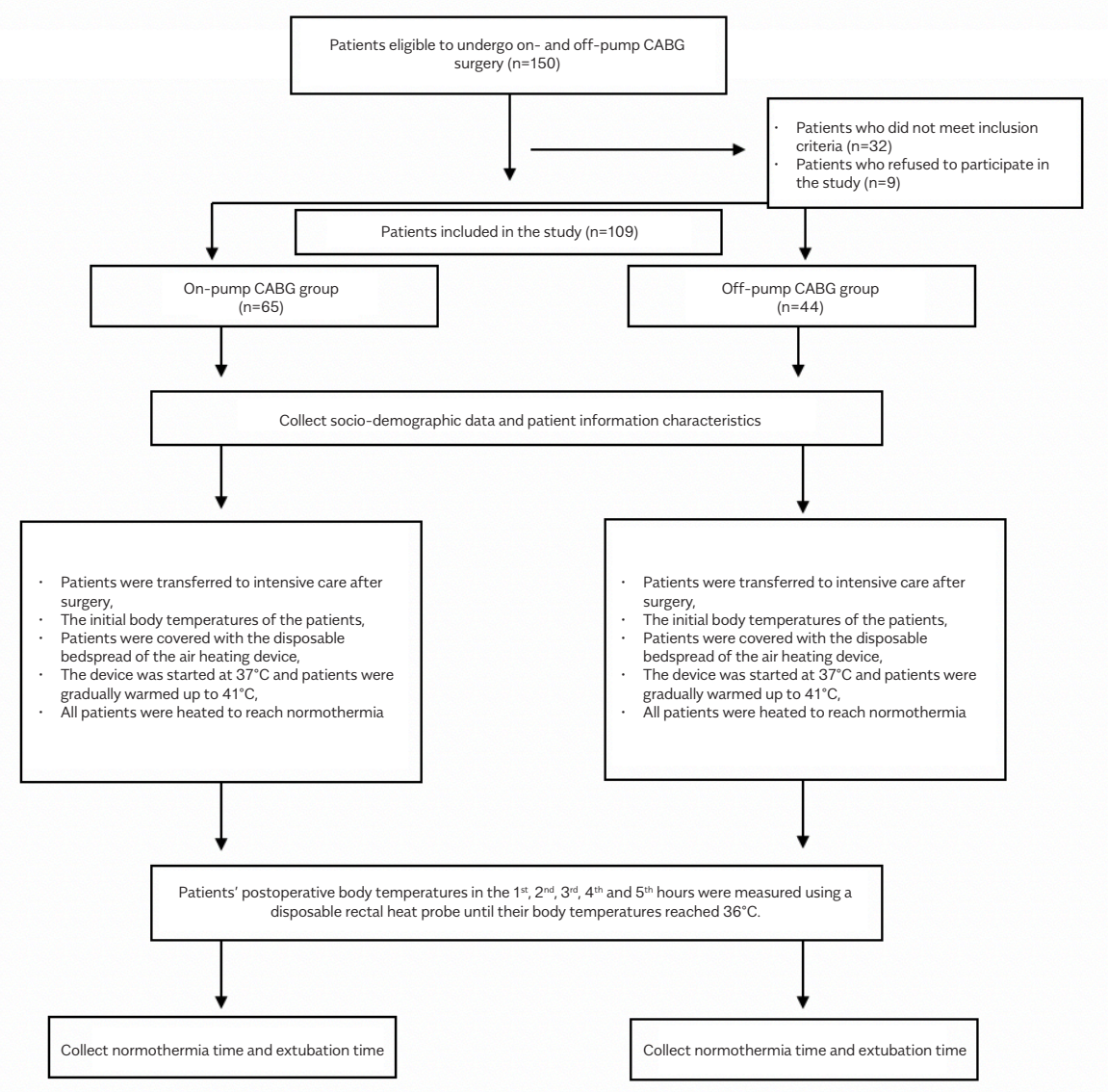

Figure 1. Study procedure

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS Inc.; Chicago, IL, USA) 18.0 software. In descriptive analysis of data, number, percentage, mean, and standard deviation were used. Additionally, independent *t*-test was used to compare the body temperature of the patients at different times, the time taken to reach normothermia, and the duration of extubation based on the on- or offpump methods and the gender of patients. Furthermore, the correlation between age and the body temperature of patients at different times, the time taken to reach normothermia, and the duration of extubation was studied using the Pearson correlation analysis. The value of $p<0.05$ was accepted as statistically significant for all findings.

Ethical Considerations

The ethical permission was obtained from the Medical Ethics Committee of the Faculty of Medicine at Afyon Kocatepe University before starting the study (2009/5-33). The written permission from the General Manager of the institution was also obtained. All patients were informed regarding the study at the outset, and their oral and written consents were obtained.

RESULTS

Descriptive statistics concerning the distributions of certain features of patients are presented in Table 1. According to this, 27.7% of the on-pump group are women, 72.3% are men; 38.6% of the off-pump group are women and 61.4% are men. The average ages of patients were noted to be 63.64±10.22 years in the on-pump group and 65.98±9.91 years in the off-pump group. Upon analyzing the comorbidities of patients participating in the study alongside their coronary artery disease, the most frequent diseases in both groups were observed to be diabetes mellitus (on-pump=44.6%, off-pump=40.9%) and hypertension (on-pump=46.2%, off-pump=34.1%).

The t-test results aimed at comparing the body temperature, normothermia time and extubation times of patients heated with forced air warming method based on their operative method, on- or off-pump CABG, are presented in Table 2. According to this, the preoperative body temperature, postoperative first body temperature, the second hour body temperature, and extubation time did not exhibit a significant difference depending on the operating method. However, a significant difference was observed regarding the first, third, fourth, and fifth hour body temperatures and time taken to reach normothermia based on the operating method ($p<0.05$). Notably, the off-pump group's body temperatures in the first, third, fourth, and fifth hours were higher compared with the on-pump group. Moreover, it was observed that the off-pump group's reached normothermia (145.22±72.54 minutes) earlier and faster compared with the on-pump group (206.84±89.30 minutes).

Table 1. Descriptive statistics concerning certain features of patients

	On-Pump			Off-Pump		
Variables	**n**	**%**	**Mean±SD**	**n**	**%**	**Mean±SD**
Age			63.64±10.22			65.98±9.91
Gender						
Female	18	27.7		17	38.6	
Male	47	72.3		27	61.4	
Diabetes mellitus	29	44.6		18	40.9	
Hypertension	30	46.2		15	34.1	
Diabetic neuropathy	2	3.1		1	2.3	
Chronic renal failure	2	3.1		1	2.3	
Chronic obstructive Pulmonary disease	10	15.4		11	25.0	
Cerebrovascular event	4	6.2		2	4.5	

SD: Standard deviation

Table 2. Comparison of patients' temperature, time of regaining normothermia, and time of extubation based on groups

	On-Pump	Off-Pump	
Variables	**Mean±SD**	**Mean±SD**	**p**
Preoperative BT (°C)	36.38±0.31	36.39±0.26	0.956
Postoperative First BT (°C)	34.66±0.54	34.90±0.82	0.081
1. Hour BT (°C)	34.94±0.62	35.40±0.66	0.000*
2. Hour BT (°C)	35.63±2.31	35.88±0.67	0.491
3. Hour BT (°C)	35.84±0.63	36.23±0.60	0.002*
4. Hour BT (°C)	36.24±0.77	36.69±0.79	0.008*
5. Hour BT (°C)	36.42±0.63	37.06±0.88	0.000*
NT (Minute)	206.84±89.30	145.22±72.54	0.000*
ET (Hour)	5.23±2.37	4.85±2.26	0.399

*p<0.05. SD: Standard deviation; BT: Body temperature; NT: Normothermia time; ET: Extubation time

Table 3. Comparison of patients' temperature, time of regaining normothermia and time of extubation in terms of gender

Variables	**Female Mean±SD**	**Male Mean±SD**	**p**
Preoperative BT (°C)	36.34±0.26	36.40±0.30	0.329
Postoperative First BT (°C)	34.73±0.55	34.77±0.73	0.791
1. Hour BT (°C)	35.16±0.61	35.11±0.70	0.739
2. Hour BT (°C)	35.64±0.70	35.78±2.17	0.701
3. Hour BT (°C)	36.09±0.69	35.94±0.62	0.268
4. Hour BT (°C)	36.59±0.85	36.32±0.78	0.140
5. Hour BT (°C)	36.76±0.94	36.59±0.70	0.372
NT (Minute)	163.42±87.17	190.74±87.59	0.131
ET (Hour)	5.04±2.90	5.10±2.02	0.903

SD: Standard deviation; BT: Body temperature; NT: Normothermia time; ET: Extubation time

The *t*-test results that aimed to compare the body temperature, normothermia and extubation times of patients heated with forced air warming method according to gender are presented in Table 3.

Test results revealed that all body temperatures, and times of extubation and normothermia did not exhibit a significant differences according to gender (p>0.05). Women and men presented values identical to each other regarding all parameters.

Pearson correlation coefficient of relationship between variables (the body temperatures, normothermia times, and extubation times) and age are presented in Table 4. According to this table, a statistically significant relation was not observed between a patient's body temperature and their age (p>0.05). However, low but positive and significant (p<0.05) correlation was observed between the times of extubation (r=0.197) and age, as well as time taken to reach normothermia (r=0.237) and age. These values showed that patients' times of extubation and normothermia increase, even if just slightly with the increase in their age (Table 4).

DISCUSSION

Perioperative hypothermia, which is unwelcome complication in cardiac surgery performed with the off-pump method, begins before the preoperative period (1 hour before anesthesia) and continues until the postoperative period (first 24 hours after anesthesia) (Sajid, Shakir, Khatri & Baig, 2009). The hypothalamus regulates the core temperature of the body under normal conditions. Intravenous and inhalation anesthetics, particularly inhaling cold gases, as well as heat loss through body cavities and the fact that anesthetized patients' remain naked and unmoving in cold operating rooms, inhibit the hypothalamus and raises the threshold stimulation degree. Therefore, the thermoregulatory system is delayed. Consequently, hypothermia continues in the postoperative period as well. In addition to the hypothermia described above, in patients operat-

Table 4. Relationship of patients' temperature, time of regaining normothermia, and time of extubation with their ages

	Preop. BT (°C)	**Postop. First BT (°C)**	**1. Hour BT (°C)**	**2. Hour BT (°C)**	**3. Hour BT (°C)**	**4. Hour BT (°C)**	**5. Hour BT (°C)**	**NT (Min)**	**ET (Hour)**
r	0.133	0.068	0.046	0.112	0.124	0.130	0.008	0.197	0.237
p	0.168	0.483	0.638	0.245	0.207	0.200	0.945	0.040*	0.013*

*p<0.05. R: Pearson Correlation Coefficient; BT: Body temperature; NT: Normothermia time; ET: Extubation time

ed with the on-pump method, the body temperature is reduced intentionally during operation by using the pump and cardiopulmonary bypass and a specific period of hypothermia is induced. Consequently, achieving normothermia (36°C) early in the postoperative period after the intended and unintended hypothermia of both methods of cardiac surgery has the utmost significance in terms of the hemodynamic parameters and patient comfort during this period (Koyuncu, Yava, Kürklüoğlu, Güler & Demirkılıç, 2011). The literature states that it takes 4–8 hours for peripheral perfusion to return to normal in patients undergoing on-pump cardiac surgery (Kimberger & Kurz, 2008; Okutan & Kutsal, 2001). Furthermore, the literature emphasizes the necessity to ensure an ideal body temperature in the postoperative period by using various methods (forced air warming, cotton blankets, and giving hot liquids, etc.) (Campbell et al., 2012; Hooper et al., 2010). In their study, Villamaria et al. (1997) stated that patients heated with forced air warming (first 1 hour) reach normothermia in lesser time compared with patients heated with blankets (1–2 hours). In our study, all the off-pump patients reached the desired body temperature within 145 minutes and the on-pump patients within 206 minutes. Notably, the off-pump group's time for regaining normothermia was statistically significant compared with the on-pump group, besides the group taking less time to do so. The result for patients undergoing on-pump method might be related to bringing down the body temperature intentionally through cardiopulmonary bypass and pump during the surgical procedure in addition to the circumstances regarding hypothermia endured by patients who underwent off-pump method.

Hypothermia causes delays in extubation and increased demand for mechanical ventilation. Moreover, it increases the ICU time and the overall hospitalization period. Because of all these complications, hypothermia increases the medical costs (Campbell et al., 2012; Hooper et al., 2010). Approximately 500,000 CABG surgeries are performed annually in the United States of America costing the healthcare system considerable amounts (Bansal,Thai, Hsu,-Sai-Sudhakar, Goldman, & Rhenman, 2013). "Fast-track" protocols have been developed to provide early discharge by ensuring safe and fast postoperative healing, thereby reducing the costs (Toraman, Karabulut & Alhan, 2000). Early extubation, which is defined as extubation in the first 5 hours after open heart surgery, is highly significant in this "fast track" system (Uncu et al., 2004). The literature mentions that hypothermia may lead to delays in early extubation (Villamaria et al., 1997). In Uysalel's (1997), study which was conducted to analyze the effects of the three active heating methods on hemodynamics and the extubation time after cardiopulmonary bypass, it was observed that the extubation time in patients who were heated with warm air (Warm Air Hyperthermia system) was 7.5±0.9 hours, and the difference was statistically significant. In our study, the extubation period was determined to be 5.23 hours in the on-pump group and 4.23 hours in the off-pump group. Although not statistically significant, it was established that the off-pump group was extubated after a shorter period. The reason why no statistically significant differences were observed between the two groups regarding the average extubation time could be related to the difference in the number of patients included in the groups, as well as the similarities of the extubation times between the groups. According to the literature, normothermia is one of the basic factors that determines the right time to extubate patients who underwent CABG (Saad & Aladawy, 2013). This statement is supported by this study's finding that the off-pump group required less time to reach normothermia compared with the on-pump group.

Coronary artery disease mortality rate was 2.7 for males per 1000 and 1.9 for females per 1000 in the United States (based on 2011 mortality data) (Mozaffarian et al., 2015). The mortality rates were 7.3 for males per 1000 and 3.8 for females in Turkey (based on 1999–2014 mortality data) (Onat et al., 2015). However, one-third of CABG operations currently are performed on women (Kaya, İyigün, İyigün, Bakır & Yeniterzi, 2013). Furthermore, the operative mortality is high in women undergoing CABG than men, with the relative risk ratios varying from 1.4 to 4.4 (Güneri & Özpelit, 2010). Complications, such as stroke, bleeding, prolonged mechanical ventilation, and cardiac insufficiency after CABG are more frequent in women (Güneri & Özpelit, 2010). Therefore, it is imperative that women who have perioperative hypothermia, which can trigger complications, reach normothermia earlier. In this study, no statistical differences were observed regarding body temperature, time of extubation, and time to reach normotheirmia because of gender. However, a relative difference regarding the time to reach normothermia between male and female patients, al-

beit not statistically significant. In other words, the time to reach normothermia was shorter in female patients (163.42±87.17 minutes) than male patients (190.74±87.59 minutes). The reason for not considering this relative difference as statistically significant could be attributed to the small sample size of groups. Winslow et al. (2012) used three different thermometers to compare the body temperature of patients who underwent major surgical procedures and stated that no meaningful statistical differences were observed based on gender among the groups of their study.

Patients who undergo CABG are mostly aged 60 years and above with thermoregulatory system slowdown (Demirarslan, 2015). The average age of the on-pump group was observed to be 63.64±10.22 years, and the off-pump group's average age was noted to be 65.98±9.91 years. The literature indicates age as a risk factor for hypothermia (Benson et al., 2012; Hooper et al., 2010). When Pearson correlation coefficient assessed the relation between patients' times of extubation and normothermia, and their age, a poor but positive and significant ($p<0.05$) correlation was observed between times of extubation ($r=0.197$) and regaining normothermia ($r=0.237$) and age. This finding demonstrates that along with the increase in patients' age, their time of extubation and regaining normothermia also increases, even if only slightly. It was considered that this situation, as stated in the literature (Chambers & Allan, 2017), might result from a decrease in subcutaneous tissue and metabolism, low vasoconstrictor and compensatory cardiac capacity, and low muscle volume in geriatric patients. It was mentioned in one study that elderly patients had hypotheirmia more often than the young patients (Winslow et al., 2012). In a study conducted a study of adult patients who underwent surgical procedures and concluded that age is a defining factor, which affects the body temperature (Jardeleza, Fleig, Davis, & Spreen-Parker, 2011).

Study Limitations

One of the limitations of this study was the small sample size. Moreover, the study lacked control group and randomization.

CONCLUSION AND RECOMMENDATIONS

Consequently, it was determined that heating patients with forced air warming considerably affects the time at which patients regain normothermia after on- and off-pump CABG. Critical complications caused by hypothermia risk patient's safety. Therefore, all healthcare personnel, particularly perioperative nurses, are responsible for preventing perioperative hypothermia. After highly risky and major surgeries, such as CABG, nurses should evaluate patients' hypothermia risk factors and hypothermia indications, record them, and frequently monitor the body temperature. The care interventions devised by nurses as part of monitoring and evaluation should include appropriate heating methods that are most suitable for each patient. We suggested the use of forced air warming method to ensure patients regain normothermia soon after CABG. In addition, it is imperative to use thermal flow charts that have been designed to monitor, regulate, and evaluate patients' body temperatures, as well as perform the activities indicated on these charts. In conclusion, further studies with larger group of patients and a better time span will be beneficial for both literature and the concerned departments.

Ethics Committee Approval: Ethics committee approval was received for this study from the Clinical Research Ethics Committee of of Afyon Kocatepe University (2009/5-33).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – Y.C.; Design – Y.C., M.Y.vG.; Supervision – Y.C., M.Y.vG.; Resources – Y.C., M.Y.vG.; Materials – Y.C.; Data Collection and/or Processing – Y.C.; Analysis and/or Interpretation – Y.C., M.Y.vG., E.A., İ.K.; Literature Search – Y.C., M.Y.vG.; Writing Manuscript – Y.C., M.Y.vG.; Critical Review – Y.C., M.Y.vG., E.A., İ.K.; Other – Y.C., M.Y.vG., İ.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

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