Original Article

Comparison between Forced Air and Intravenous Fluid Warmer in Gynecologic Laparoscopic Surgery: A Randomized Trial

Warunee Boayam BNS[1], Phongthara Vichitvejpaisal MD, PhD[1], Pawan Suton BNS[1], Sarisa Tapala BNS[2]

[1] Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand
[2] Department of Perioperative Nursing, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

Background: Peri-operative hypothermia is a common problem in anesthesia.

Objective: To compare the difference between core and room temperature in patients undergoing gynecologic laparoscopic surgery by using forced air and intravenous fluid warmer.

Materials and Methods: After IRB approval COA: Si201/2016, the present study has been registered at ClinicalTrials.gov NCT02990429. A prospective experimental study was conducted with 90 patients. All participants were randomized into two groups, A) receiving intra-operative forced air warming, and B) having intra-operative intravenous fluid via a flowing warmer. The core and room temperatures were measured at 15-minute interval until the end of surgery. The data was expressed as means and standard deviation. The *p*-value lower than 0.05 was considered statistical significance at 95% confidence interval.

Results: Eighty-six patients completed the trial. Temperature of both groups appeared to decrease insignificantly after induction, but it showed a slightly lower in group B (22.8±1.3°C) as compared to group A (22.9±1.0°C). In addition, group A (35.4±0.7°C) presented a little higher temperature than that of group B (35.2±0.8°C) in the recovery room.

Conclusion: The forced air warmer was as clinically effective as the fluid warmer in gynecologic laparaoscopic surgery.

Keywords: Hypothermia, Gynecologic laparoscopic surgery, General anesthesia

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Peri-operative hypothermia is a common problem in anesthesia. It has been defined as a core temperature below 36°C[(1)]. The reasons why patient undergoing gynecologic laparoscopic surgery has this adverse event are reduced metabolic heat production, heat redistribution from the core to the periphery, impaired thermoregulation, cool carbon dioxide gas insufflation, surgical irrigation solution, and cool environment[(2)]. The sequelae are myocardial ischemia as hypothermia increases plasma catecholamine, surgical site infection as hypothermia diminishes wound tissue O_2 tension, and coagulopathy as hypothermia impairs platelet function[(3-6)].

Studies claim that peri-operative heat loss occurs by radiation (60%), convection (25%), and evaporation (10%)[(7)]. These are due to the difference between peripheral tissue and ambient temperature, air circulation around the body, and vasodilatation.

In daily practice, most anesthesia personnel warm patient peri-operatively by using force air warmer or intravenous fluid warmer. Thus, investigators would like to compare the difference between core and room temperature in patients undergoing gynecologic laparoscopic surgery by using forced air or intravenous fluid warmer.

Materials and Methods

The Siriraj Institutional Review Board approved the present study COA: Si201/2016, and written informed consent was obtained from all subjects. Study setting has been registered at ClinicalTrials.gov NCT02990429. The present study was conducted at the Department of Obstetrics and Gynecology, Siriraj Hospital.

Ninety patients were enrolled in the present study, 84 patients for calculated sample size and six patients for dropout purpose. All patients underwent general

Correspondence to:

Vichitvejpaisal P. Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Wang Lang Road, Bangkoknoi, Bangkok 10700, Thailand.
Phone: +66-2-4197978, **Fax**: +66-2-4113256
Email: phongthara@gmail.com

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anesthesia for elective gynecologic laparoscopic surgery. Inclusion criteria were patients aged between 18 and 65, elective case, the American Society of Anesthesiologists [ASA] physical status class I to III, body mass index [BMI] 25 to 30 kg/sq.m, surgical time longer than 90 minutes. Exclusion criteria were the core temperature less than 35°C or more than 38°C. Withdrawal or termination criterion was the change of laparoscopic surgery to exploratory laparotomy.

On the day of surgery, participants signed the informed consent and were randomized equally into two groups, A) receiving intra-operative forced air warming (Bair Hugger®, Arizant Healthcare Inc., St. Eden Prairie, USA), and B) having intra-operative intravenous fluid via a fluid warmer (Ranger Warmer®, Augustin Medical, Inc., Prairie, USA).

After application of standard monitors, anesthesia was induced intravenously with fentanyl 1 to 2 mcg/kg or morphine 0.1 to 0.2 mg/kg, propofol 1.5 to 2.5 mg/kg, cisatracurium 1 to 1.5 mg/kg or atracurium 0.6 mg/kg. Anesthesia was maintained with sevoflurane, air, O_2 supplemented with fentanyl or morphine. Core temperatures were measured with an electronic thermometer via tympanic membrane.

Intra-operatively, core temperatures, and room temperatures were measured at 15-minute interval until the end of surgery.

Postoperative data were measured at 15-minute interval at the recovery room. Data consisted of vital signs, core temperature, room temperature, shivering, medication requirements, and use of warming device.

Group A, the warming blanket was applied on the upper part of body after induction of anesthesia. The forced air was delivered at the high setting of 43°C. At the end of anesthesia, the blanket was removed, and the patient was delivered to the recovery room with standard care. Group B, patients received intravenous fluid via a flowing warmer after induction of anesthesia. The device automatically heated fluid up to 41°C as set point. At the end of procedure, the fluid warmer was disconnected and the patient was transferred to the recovery room with intravenous fluid administered at room temperature.

Patient developing intra-operative core temperature greater than 37.5°C had to quit all devices to avoid hyperthermia.

Statistical analysis

Non-dependent t-test and Chi-square test were used to compare parametric and nonparametric data respectively. The parametric ones expressed as means and standard deviation. The *p*-value of less than 0.05 was considered statistical significance at 95% confidence interval.

Results

The 86 patients accomplished the trial, while four patients were excluded from the present study because of the failure of room temperature device.

Both groups (A = 44, B = 42) were insignificant difference with respect to age, BMI, ASA status, fluid balance, irrigation fluid, type and duration of surgery, core, and operating room temperature (Table 1).

Temperature of both groups showed to decrease insignificantly after induction (Figure 1), but it appeared slightly lower in group B (22.8±1.3°C) as compared to group A (22.9±1.0°C). In addition, group A had insignificantly higher temperature at 15, 30, 45, 60, 75, and 90 minutes interval than that of group B (Table 2).

After 15 minutes of arrival in the recovery room, group A (35.4±0.7°C) showed a little higher temperature than that of group B (35.2±0.8°C).

Table 1. Patients' characteristics (group A: Bair® hugger, group B: Ranger® warmer)

	Group A (n = 44)	Group B (n = 42)	*p*-value
Age (years), mean ± SD	46.1±6.2	46.0±6.2	0.946
BMI (kg/m^2), mean ± SD	27.0±1.7	26.8±1.8	0.678
Type of surgery, n (%)			0.349
Total Lap. hysterectomy	18 (40.9)	24 (57.2)	
Lap. myomectory	3 (6.8)	4 (9.5)	
Total Lap. hysterectomy Bilateral dalphincgo-oophorectomy	15 (34.1)	10 (23.8)	
Other	8 (18.2)	4 (9.5)	
ASA physical status, n (%)			0.813
I II III	23 (52.3) 20 (45.4) 1 (2.3)	22 (52.4) 18 (42.9) 2 (4.7)	
Core temp: pre-operative (°C), mean ± SD	36.6±0.4	36.6±0.4	0.895
Core temp: pre-induction (°C), mean ± SD	35.8±0.6	35.9±0.6	0.833
Operating theatre temp (°C), mean ± SD	23.5±1.1	23.5±1.2	0.704
Surgical time (minutes), mean ± SD	166.0±57.1	170.7±49.0	0.684
Fluid balance (ml), mean ± SD	984.1±505.4	957.1±382.3	0.782
Irrigated water (ml), mean ± SD	756.8±552.1	833.3±633.0	0.551

BMI = body mass index; Lap. = laparoscopic; ASA = American Society of Anesthesiologists; temp = temperature

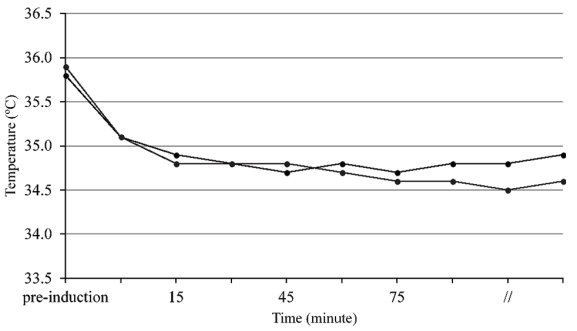

Figure 1. Mean temperature in patients receiving forced air warming (Bair® hugger) and intravenous fluid warmer (Ranger® warmer).

Table 2. Room temperature between A: Bair® hugger, B: Ranger® warmer

Room temperature (minute)	Group A (n = 44) mean ± SD	Group B (n = 42) mean ± SD	*p*-value
0	23.0±1.1	23.0±1.2	0.998
15	22.9±1.0	22.8±1.3	0.717
30	22.7±1.1	22.7±1.2	0.803
45	22.6±1.0	22.6±1.2	0.838
60	22.5±1.0	22.4±1.3	0.673
75	22.4±1.0	22.3±1.3	0.748
90	22.3±1.0	22.3±1.1	0.817
Recovery room (minute)			
0	35.3±0.7	35.0±0.9	0.108
15	35.4±0.7	35.2±0.8	0.240
30	35.5±0.7	35.2±0.8	0.109
45	35.6±0.7	35.4±0.7	0.284
60	35.6±0.7	35.5±0.7	0.612
75	35.7±0.7	35.6±0.7	0.486
90	35.8±0.7	35.7±0.6	0.475

Afterwards, there were no differences in temperature between the two groups (Table 2).

Four patients in group B and one patient in group A had mild shivering without the needs of any treatment such as opioids or warmed blankets.

Discussion

The demographic characteristics of both groups were similar. After 15 minutes of induction, group A and B insignificantly showed to decrease in temperature and appeared to maintain a steady stage throughout the procedure, with a slightly higher in group A.

The forced air warmer seemed to be an effective warming technique. Feroe and Augustine supported this in the present study on effectiveness of convective warming therapies in the PACU[8]. In addition, Adriani and Moriber claimed that conventional intra-operative forced-air warming still offered benefit[9]. However, the decreasing of temperature might due to the warmer at the high setting of 43°C, yielded a circulating flow only on the upper part of patient's torso. As a result, the body heat could easily loss from its remaining part. This also mentioned in the present study performed by Wagner et al[10].

Therefore, if the forced air warmer used to apply all over patient's body, it could have alleviated heat loss efficiently. Apparently, Bernthal[11] and many other researchers confirmed that the device was the most effective means to prevent hypothermia and suggested to use it routinely[11-13].

On the other hand, as a patient was in lithotomy position with both arms laid aside the trunk and the whole body was draped over at the beginning of laparoscopic procedure; an anesthetist had to use a long extension tube for intravenous fluid management. Thus, the warmed fluid at the set point of 41°C, lost warmth en-route through the patient. Therefore, in a cool operating theatre, the distance between source of fluid and site of needle cannulation should be as short as possible. Consequently, this generated a troublesome intra-operative fluid administration. In addition, the fluid flow rate played a role in bodily heat control, as the slower the rate was, the lower the temperature would be. These findings agreed with Faries et al who performed the present study on the relationship between temperature to distance and flow rate of warmed intravenous fluids in pediatrics[14]. Presson et al were concerned about the large volume of fluid relative to patient size and suggested a slow rate infusion[15]. Moreover, Rein et al stated that warmed water with pulsating negative pressure was better than forced air warmer[16]. Finally, Turner et al, on simulated clinical evaluation of fluid warming devices, revealed that to achieve temperature close to 37°C, a flow rate of 150 ml/minute was needed[17].

Interestingly, Seo et al suggested that the deceasing rate of temperature was related inversely to the flow rate and directly to the catheter length. Accordingly, it might need a rapid infusion pump with adequate heating system at a high flow rate and locating the warmer close to patient to keep the heating effect[18].

In the recovery room, all participants were covered by warmed blanket. The core temperature of both groups showed insignificant difference. However, the forced air warmer seemed to keep body warmed longer than that of the fluid warmer. This agreed with Patel et al who reported that patients receiving convective

warming were more likely to leave the operating room normothermic and had higher central temperature during the first 30 minutes in the recovery room[19].

Conclusion

The forced air warmer was as clinically effective as the intravenous fluid warmer in preventing hypothermia during gynecologic laparoscopic surgery.

What is already known on this topic?

Currently, most anesthesia personnel prevent patients from hypothermia by using forced air and/or intravenous fluid warmer during gynecologic laparoscopic surgery. Forced air warming system are claimed to be effective in preventing peri-operative hypothermia and shivering. The intravenous fluid warmer usage is still questionable on its effectiveness.

What this study adds?

Other than the rate of fluid administration, the distance between the source of fluid and the site of intravenous cannulation was of concern since the warmth could easily be loss en-route to the patients.

Potential conflicts of interest

The authors declare no conflict of interest.

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