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Incidence of Inadvertent Perioperative Hypothermia in Pediatric Laparoscopic Surgery: a Prospective Observational Single-Center Study

Pediyatrik Laparoskopik Cerrahide İstenmeyen Perioperatif Hipotermi İnsidansı: Tek Merkezli Gözlemsel Araştırma

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ÖZ

Amaç: Pediyatrik yaş grubu yetersiz yağ dokusu ve gelişmemiş termoregulatuar cevapları nedeniyle istenmeyen perioperatif hipotermi (İPH) için risk grubudur. Laparoskopik cerrahi altındaki pediyatrik yaş grubundaki İPH sıklığını saptamayı amaçladık.
Araçlar ve Yöntem: Bu araştırma gözlemsel prospektiftir. Genel anestezi altında laparoskopik cerrahi uygulanan pediyatrik hastalar (1-18 yaş) değerlendirildi. Hastaların timpanik membran sıcaklıkları (°C) anestezi indüksiyonu öncesi (T_0) ve sonrasında cerrahi sırasında her 15 dakikada ölçüldü.
Bulgular: Toplam 100 hasta değerlendirildi. İstenmeyen perioperatif hipotermi sıklığı 13(%13) saptandı. Elektif cerrahilerdeki İPH sıklığı acil cerrahilerdekinden daha fazladır (<0.001). Toplam 28 elektif hastanın 11'inde (39.3%) İPH gelişti. Hipotermik hastaların yaş, vücut kitle indeksi, intravenöz sıvı volümü ve insufle edilen CO_2 volümünün normotermik hastalarınkinden istatiksel olarak daha düşük olduğu saptandı. Normotermik ve hipotermik hastaların T_0 (°C) (37.8±0.53 vs 36.8±0.60, sırasıyla, 95% CI, 37.6 to 37.8, p<0.001) arasında anlamlı istatiksel farklılık saptandı. Toplamda, ilk 30 dakikada vücut sıcaklığında yaklaşık 0.7 °C azalma gelişti.
Sonuç: Pediyatrik yaş grubundaki laparoskopik cerrahi sırasında İPH sıklıkla gelişmektedir. Kullandığımız güncel sıcaklık yönetimi ve pasif ısıtma sistemleri hipotermiden korumayı sağlamak için yeterli görünmemektedir.

Anahtar Kelimeler: genel anestezi; istenmeyen hipotermi; laparoskopi; pediyatrik; vücut sıcaklık değişimi

ABSTRACT

Purpose: The pediatric age group is a risk group for Inadvertent perioperative hypothermia (IPH) due to insufficient subcutaneous adipose tissue and underdeveloped thermoregulatory responses.
We aimed to determine the frequency of IPH in the pediatric age group undergoing laparoscopic surgery.
Materials and Methods: The study is prospective observational. Pediatric patients (1-18 years old) who underwent laparoscopic surgery under general anesthesia were evaluated. The tympanic membrane temperature measurements of the patients (°C) were recorded before anesthesia induction (T_0) and then every 15 minutes during the surgery.
Results: A total of 100 patients were evaluated. The frequency of inadvertent perioperative hypothermia was detected as 13(13%). The frequency of IPH in elective surgery patients was higher than in emergency surgery (<0.001). IPH occurred in 11 of a total of 28(39.3%) patients during elective surgery.
Age, body mass index, intravenous fluid volume, and insufflated CO_2 volume of hypothermic patients were detected to be statistically significantly lower than the normothermic group. A significant statistical difference was detected between T_0 (°C) of normothermic and hypothermic patients (37.8±0.53 vs. 36.8±0.60, respectively, 95% CI, 37.6 to 37.8, P<0.001). In total, a decrease of approximately 0.7 °C in body temperature was observed in the first 30 minutes.
Conclusion: IPH frequently develops during laparoscopic surgeries in the pediatric age group. The current temperature management practices and passive heating systems that we use do not seem adequate to provide protection from hypothermia.

Keywords: accidental hypothermia; body temperature changes; general anesthesia; laparoscopy; pediatric

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INTRODUCTION

Inadvertent perioperative hypothermia (IPH) is defined as the uncontrolled core temperature decrease below 36°C during the surgical procedure. Hypothermia causes many complications, such as increased surgical wound infection, cardiac rhythm disturbance, tendency to bleeding, and prolonged effects of anaesthetic drugs. These complications cause increased morbidity and mortality.[1] In the current literature, the incidence of IPH during surgery is reported as 50-70%.[2] The incidence of IPH is influenced by many factors, such as age, gender, body mass index (BMI), type of surgery, anaesthesia method, duration of surgery, operating room temperature, etc.[2]

Data on the incidence of IPH in the pediatric age group are limited.[3] The pediatric age group is among the risk groups for perioperative hypothermia due to insufficient subcutaneous adipose tissue and underdeveloped thermoregulatory responses.[4] Therefore, perioperative temperature monitoring should be done more frequently in this age group.[5] Strict body temperature monitoring starting from the preoperative period is among the safe surgical standards for this age group.[5]

Laparoscopic surgery has been widely used in the pediatric age group due to its advantages for the last few decades.[6, 7] In addition to its advantages, it also has disadvantages, such as inadvertent hypothermia. It is often applied under general anaesthesia. In addition to the hypothermic effect of general anaesthesia, IPH may develop due to the CO_2 used for pneumoperitoneum during laparoscopic surgery.[8] However, pediatric data on this subject are insufficient.[3, 9]

The primary purpose of our research is to determine the frequency of IPH in the pediatric age group undergoing laparoscopic surgery. Our secondary aim is to test the adequacy of our standard practices and equipment available in our hospital to maintain perioperative normothermia.

MATERIALS and METHODS

Study Design and Ethics

The research was planned as prospective and observational. Ethical approval for this study was obtained from Kirsehir Ahi Evran University Clinical Research Ethics Committee (Date:10.03.2020, No:2020-04/05). This research was planned considering the current Helsinki criteria. During the preoperative anaesthesia evaluation, the patients included in the study and their parents were informed about the study. Patients and/or their families signed a research consent form, and written consent was obtained.

Inclusion and Exclusion Criteria

Pediatric patients (1-18 years old) who underwent elective or emergency laparoscopic surgery under general anaesthesia in Kirsehir Training and Research Hospital between 01.04.2020 and 01.04.2021 were enrolled in the study.

Based on the American Society of Anesthesiologists (ASA) physical status classification risk group I-II, 100 patients between 1-18 years old were included in the study.

Patients medically treated due to hypothyroidism, hyperthyroidism, and cardiac arrhythmia and patients with neurological diseases (congenital or acquired) were excluded from the study.

Practice

When the patients were brought into the operating room for operation, non-invasive blood pressure (NIBP), peripheral oxygen saturation (SpO_2) and ECG monitoring were performed before anaesthesia was applied.

The tympanic membrane temperature measurements of the patients (°C) were recorded before anaesthesia induction (T_0) and then every 15 minutes during the surgery (T_n) with Braun IRT6520 (Braun GmbH, Kronberg, Germany). The change in tympanic temperature (Δ_n) during the surgical procedure was calculated by the following formula: $\Delta_n=T_0-T_n$.

Vascular access was established in the morning of the surgery, and 1/3 Izomix infusion was administered intravenously at a rate of 4 $ml.kg^{-1}h^{-1}$.

Standard Anaesthesia Procedure

After preoxygenation, 2-3 $mg.kg^{-1}$ propofol and 0.6 $mg.kg^{-1}$ rocuronium bromide were administered intravenously

(iv) for the induction of general anaesthesia. After the patients were intubated, maintenance was provided with 4 Lt O_2-Air (50-50%) and 2% sevoflurane. Rocuronium bromide 0.1 $mg.kg^{-1}$ was added, when necessary, during the surgical procedure. At the end of the surgical procedure, 0.02 $mg.kg^{-1}$ atropine and 0.05 $mg.kg^{-1}$ neostigmine were administered intravenously for decurarization. For postoperative analgesia, 10 $mg.kg^{-1}$ iv paracetamol was administered.

Standard Laparoscopic Surgery Procedure

Surgical field sterilization was performed following the induction of anaesthesia. The patients were covered with a single layer of sterile standard surgical cotton drapes. For laparoscopic surgery, Stryker Endoscopy (Optical Court, San Jose, CA, USA) was used. After placement of the trocars, CO_2 was insufflated so that the intraabdominal pressure was established up to a maximum of 12 cmH_2O to provide pneumoperitoneum.

Procedure to Prevent Hypothermia

In all operations, the heated mattress pad system MEDWARM W-500D (Istanbul Medical, Istanbul, Turkey) set at 37 °C was covered on the operating table, and pediatric patients were placed on it. The temperature and humidity of the operating room were regularly measured by the air conditioning system in the room, and the airflow of the room was regulated according to these values.

When the tympanic membrane temperature measurement was detected as <36 °C during the surgical procedure, the patient was considered to have IPH. These patients were actively warmed by using the Thermacare TC3249 (Gaymar, New York, USA) warming system.

Outcomes

The primary endpoint of this study was to detect the frequency of IPH.

Secondly, the basic characteristics of patients in the hypothermia group were compared with those in the normothermia group BMI ($kg.m^{-2}$), anaesthesia times (min), operation times (min), operation room temperature (ºC), operation room humidity (%), infused intravenous fluid volume (mL), insufflated CO_2 volume (l), T_0(ºC).

Statistical Analysis

Data analysis was performed using the IBM SPSS v.23.0 (IBM Corp., Armonk, NY, USA) statistical package program. Descriptive statistics as frequency (n), percent (%), mean, standard deviation (SD), median, 25th - 75th quartiles, and mean- 95% CI (Confidence Interval) were given. Chi-Square ($\chi 2$) test or Fisher's Exact Test was used to examine the differences between categorical variables. The conformity of the data to normal distribution was evaluated with Kolmogorov-Smirnov and Shapiro-Wilk's tests. In the comparison of normothermic and hypothermic groups, the Mann-Whitney U test or Independent-Samples *t*-Test test was applied according to the normality of distribution of the data. $p<0.05$ was considered significant.

RESULTS

A total of 100 patients were evaluated. The frequency of inadvertent perioperative hypothermia was detected as 13(13%). For 12(12%) of these patients, hypothermia occurred in the first 30 minutes. Baseline characteristics are presented in Table 1.

ASA physical status classifications of patients were ASA I 94(94%) and ASA II 6(6%). Patients underwent emergency laparoscopic surgery (appendectomy (n=72)) or elective laparoscopic surgery (inguinal hernia (n=25) and laparoscopic orchiopexy (n=3)).

The frequency of IPH in elective surgery patients was higher than in emergency surgery ($p<0.001$) (Table 1). IPH occurred in 11 of a total of 28(39.3%) patients during elective surgery.

Age, BMI, infused intravenous fluid volumes, and insufflated CO_2 volumes of hypothermic patients were detected as statistically significantly lower than those in normothermic patients (Table 1).

T_0 of all patients was detected at 37.7±0.65 °C. There was a statistically significant difference between normothermic

and hypothermic patients (37.8±0.53 vs. 36.8±0.60, respectively, 95% CI, 37.6 to 37.8, p<0.001).

In total, a decrease of approximately 0.7 °C (0.70 [0.40-0.87]) in body temperature was observed in the first 30 minutes. The change in tympanic temperature during surgery is presented in Figure 1. The body temperature change of hypothermic patients (Δ_{30}) was higher than in normothermic patients (0.90 [0.75-1.12] vs 0.70 [0.30-0.80], p=0.008, respectively).

Table 1. Baseline characteristics of all laparoscopic surgery patients. Comparison of normothermic and hypothermic patients

Variables		Patients (n=100)	Normothermia (n=87)	Hypothermia (n=13)	p
Sex, *n* (%)	Female	27 (27%)	26 (26%)	1 (1%)	0.08*
	Male	73 (73%)	61 (61%)	12 (12%)	
ASA, *n* (%)	I	94 (94%)	82 (82%)	12 (12%)	0.78*
	II	6 (6%)	5 (5%)	1 (1%)	
Surgery type	Emergency	72(72%)	70 (70%)	2 (2%)	<0.001†
	Elective	28(28%)	17 (17%)	11 (11%)	
Age (year)		9.94±4.44	10.66±4.27	5.15±1.91	<0.001‡
		10.50 [6.00–13.75]	11.00 [8.00–14.00]	5.00 [3.50–6.50]	
		(9.06 to 10.82)	(9.75 to 11.57)	(4.00 to 6.31)	
BMI ($kg.m^{-2}$)		17.64±3.72	18.04±3.63	14.95±3.33	0.001‡
		17.80 [14.73–20.28]	18.00 [16.00–21.60]	13.90 [13.80–14.80]	
		(16.90 to 18.38)	(17.27 to 18.82)	(12.94 to 16.97)	
Anaesthesia times (min)		52.31±9.62	52.64±9.53	48.77±9.88	0.145‡
		53.00 [44.00–60.00]	53.00 [44.00–60.00]	45.00 [40.00–57.00]	
		(50.40 to 54.22)	(50.81 to 54.87)	(42.80 to 54.74)	
Operation times (min)		42.44±9.20	42.79±9.20	40.15±9.22	0.302‡
		41.50 [34.25–50.00]	42.00 [35.00–51.00]	36.00 [32.50–48.50]	
		(40.61 to 44.27)	40.82 to 44.74	34.58 to 45.72	
Operation room temperature (ºC)		22.1±0.93	22.0±0.89	22.3±1.12	0.324‡
		22.0 [22.0–22.0]	22.0 [22.0–22.0]	22.0 [21.5–23.5]	
		(21.8 to 22.2)	(21.8 to 22.2)	(21.7 to 23.0)	
Operation room humidity (%)		27.95±8.69	27.44±8.37	31.38±10.26	0.182‡
		25.00 [24.00–31.75]	25.00 [24.00–31.00]	30.00 [24.00–44.00]	
		(26.23 to 29.67)	(25.65 to 29.22)	(25.18 to 37.59)	
Intravenous fluid volume (mL)		310.10±156.65	327.01±155.82	196.92±111.83	0.006‡
		300 [200–450]	320 [200–500]	160 [130–250]	
		(279.02 to 341.18)	(293.80 to 360.22)	(129.34 to 264.50)	
Insufflated CO_2 volume (l)		20.75±12.00	21.94±11.72	12.77±11.19	0.011‡
		18.00 [12.25–28.00]	18.00 [13.00–31.00]	5.00 [5.00–21.00]	
		(18.37 to 23.13)	(19.45 to 24.44)	(6.01 to 19.53)	
T_0 (ºC)		37.7±0.65	37.8±0.53	36.8±0.60	<0.001§
		37.8 [37.2-38.2]	37.9 [37.5-38.2]	36.7 [36.3-37.0]	
		(37.6 to 37.8)	(37.7 to 37.9)	(36.4 to 37.1)	
Δ_{30}		0.68±0.63	0.61±0.57	1.14±0.84	0.008‡
		0.70 [0.40-0.87]	0.70 [0.30-0.80]	0.90 [0.75-1.12]	
		(0.55 to 0.81)	(0.49 to 0.73)	(0.63 to 1.64)	

ASA, The American Society of Anesthesiologists physical status classification; BMI, Body mass index; CO2, carbon dioxide.
T0: The body Temperature before anaesthesia induction Tn: The body Temperature (n. minute after anaesthesia induction). Δn, The change in tympanic temperature (Δ30=T0–T30)
The data are presented as n (%), mean ±SD, median [Q1-Q3], and (95%CI)
* $\chi 2$ test. †Fisher's Exact Test. ‡Mann-Whitney U Test. §Independent-Samples T Test

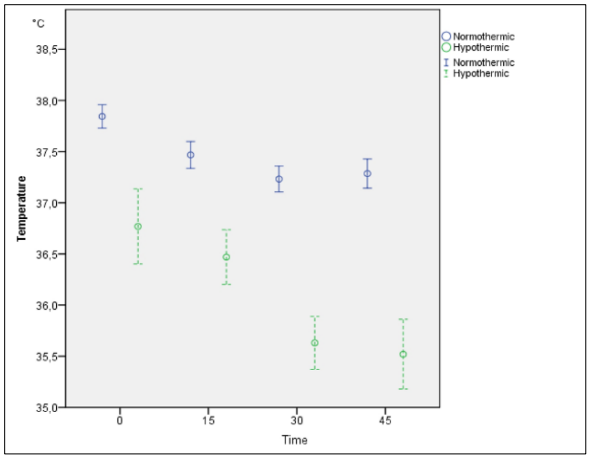

Figure 1. The change in tympanic temperature

DISCUSSION

We found IPH in 13 patients during laparoscopic surgery performed in the pediatric age group, especially in 11 patients during elective surgery. We found that the pre-induction body temperatures of patients who developed IPH were significantly lower than those of normothermic patients.

In the perioperative period, both hyperthermia and hypothermia are associated with increased patient morbidity and mortality.[1] Early detection of perioperative hypothermia is essential, as well as early detection of fatal conditions, such as malignant hyperthermia. Therefore, temperature monitoring should be done more carefully, especially in the pediatric age group.[10] Perioperative temperature monitoring has long been included as standard monitoring in guidelines for safe surgery and anaesthesia.[11]

In the beginning, especially in the first hour, the body temperature decreases suddenly due to the redistribution that develops due to the induction of anaesthesia. Later, heat loss from the body during the surgical procedure is often by radiation and convection.[10] In order to prevent temperature loss, thermal insulation of the patient's body should be provided. Many sealing systems exist, but their benefits over standard surgical drapes are unclear.[12] Research on insulation and forced air heating in temperature management in the perioperative period is ongoing, but its clinical importance has not been clearly demonstrated.[12] As a standard, we used a single layer of cotton surgical drape and applied passive heating to all patients during surgery.

According to the studies, the ambient temperature in the operating room causes heat loss from the body, and the decrease in ambient temperature increases the rate of IPH.[13] All surgeries during our study were performed in the same operating room. The ambient temperature in the operating room was similar for patients in both normothermia and hypothermia groups.

In the study by Holland et al., it was determined that a temperature loss of 0.69 °C in laparoscopic surgery and 0.47 °C in open surgery developed in infants, but no significant difference was found between the groups.[14] Similar to the research of Holland et al., we detected a decrease of approximately 0.7 °C in body temperature in the first 30 minutes.

In the studies conducted with adults, it has been determined that every 50 litres of CO_2 used causes a reduction of 0.3 °C in core temperature.[8] There are many studies on adults on the effect of heating and humidification of CO_2 on IPH, but the results are conflicting.[15-18] Contrary to this study, the amount of CO_2 used in normothermic patients in our study was significantly higher than in hypothermic patients. We attribute this to the fact that the mean age of the normothermic patient group was significantly higher than that of the hypothermic patients.

The current literature has focused specifically on both the prevention and treatment of perioperative hypothermia. Different heating methods are available to prevent the development of hypothermia.[3] In particular, standards should be established to prevent the development of IPH in pediatric cases, which are vulnerable groups, and the guidelines on this subject should be strictly followed for each patient. In the quality improvement project of Kim et al., they were able to reduce the incidence of IPH from 8.9% to 4.2% by standardizing the temperature management in the operating room.[3] We standardize the operating room temperature; moreover, we use passive heating systems in all pediatric surgeries as a standard. Although we used passive warming systems in the perioperative period, our rates of IPH in the pediatric age group in our study (13%) were higher than that found by Kim et al.

According to the study by Journeaux, a low preoperative body temperature may predispose a patient to inadvertent hypothermia during surgery.[19] Similarly, in our study, we found that the preoperative body temperatures of hypothermic patients were lower than those of normothermic patients.

In our study, we detected that the age and BMI of hypothermic patients were lower than those of normothermic patients. Depending on these results, infused intravenous fluid and insufflated CO_2 volumes were lower than hypothermic.

One of the most important of our results is that the body temperature of hypothermic patients before anaesthesia induction was significantly lower than that of normothermic patients. This can be explained by the higher preoperative body temperatures of the patients in emergency surgeries such as appendectomy. The most important result of our study is that it was found to be significantly higher in elective patients, 11 of 28 patients (39.3%). Thus, we should reconsider our preoperative temperature monitoring and protective practices (in the patient room, during patient transfer, and before surgery begins), especially in elective surgery. The local result of our research is that in order to ensure patient safety and increase quality during pediatric surgery, our standard guidelines applied in our hospital should be updated and strictly applied. For this reason, up-to-date standard equipment should be provided to prevent the development of IPH and treat hypothermia.

Standard precautions may not be sufficient to maintain normothermia, and IPH may develop.[20] In our study, despite the basic preventive measurements, IPH occurred in twelve patients (12%) even in the first 30 minutes, and these patients were actively warmed. Therefore, the anaesthesia team should monitor body temperature more closely from the beginning of the surgery, especially during laparoscopic surgery.

Limitations

Today, different methods are used for body temperature monitoring. In our study, we used a tympanic thermometer to measure the body temperature of the patients. In current literature, there are research studies suggesting that the tympanic temperature measurement does not reflect the core temperature correctly.[21] Unfortunately, we still use this method frequently both in the preoperative and perioperative periods in order to ensure standardization in our hospital. This is the limitation of our study.

Conclusion

We observed that our passive warming methods, which we use as standard practice, are not sufficient to prevent perioperative hypothermia.

IPH frequently develops during laparoscopic surgeries in the pediatric age group. Unfortunately, our current temperature management practices and passive heating systems do not seem to provide adequate protection from hypothermia.

Conflict of Interest

The authors declare that there is not any conflict of interest regarding the publication of this manuscript.

Ethics Committee Permission

Ethical approval for this study was obtained from Kırşehir Ahi Evran University Clinical Research Ethics Committee (Date:10.03.2020 No:2020-04/05).

Authors' Contributions

Concept/Design: RD, ÜÇ, FÇ, ZAE, ZK. Data Collection and/or Processing: RD, ÜÇ, FÇ, ZAE, ZK. Data analysis and interpretation: RD, ÜÇ, FÇ, ZAE, ZK. Literature Search: RD, ÜÇ, FÇ, ZAE, ZK. Drafting manuscript: RD. Critical revision of manuscript: RD, ÜÇ. Supervision: RD.

REFERENCES

1. Sessler DI. Complications and treatment of mild hypothermia. Anesthesiology. 2001;95(2):531-543.
2. Collins S, Budds M, Raines C, Hooper V. Risk Factors for Perioperative Hypothermia: A Literature Review. J Perianesth Nurs. 2019;34(2):338-346.
3. Kim P, Taghon T, Fetzer M, Tobias JD. Perioperative hypothermia in the pediatric population: a quality improvement project. Am J Med Qual. 2013;28(5): 400-406.
4. Beedle SE, Phillips A, Wiggins S, Struwe L. Preventing Unplanned Perioperative Hypothermia in Children. AORN J. 2017;105(2):170-183.
5. WHO. WHO guidelines for safe surgery 2009 – safe surgery saves life. WHO Press. Updated 01.04.2021.

http://whqlibdoc.who.int/publications/2009/9789241598552_eng.pdf. Accessed 1 February, 2020.
6. Gulack BC, Wong K, Sparks E, Ramjist J, Zhu H, Pierro A. Is the Laparotomy Here to Stay? A Review of the Disadvantages of Laparoscopy. Eur J Pediatr Surg. 2020;30(2):181-186.
7. Fujimoto T, Segawa O, Lane GJ, Esaki S, Miyano T. Laparoscopic surgery in newborn infants. Surg Endosc. 1999;13(8):773-777.
8. Ott DE. Laparoscopic hypothermia. J Laparoendosc Surg. 1991;1(3):127-131.
9. Meng-Meng T, Xue-Jun X, Xiao-Hong B. Clinical effects of warmed humidified carbon dioxide insufflation in infants undergoing major laparoscopic surgery. Medicine (Baltimore). 2019;98(27):e16151.
10. Sessler DI. Temperature monitoring and perioperative thermoregulation. Review. Anesthesiology. 2008;109 (2):318-338.
11. American Society of Anesthesiologists AC. Standards for Basic Anesthetic Monitoring. https://www.asahq.org/standards-and-guidelines/standards-for-basic-anesthetic-monitoring. Accessed 1 February, 2020.
12. Alderson P, Campbell G, Smith AF, Warttig S, Nicholson A, Lewis SR. Thermal insulation for preventing inadvertent perioperative hypothermia. Cochrane Database Syst Rev. 2014;(6):CD009908.
13. Tander B, Baris S, Karakaya D, Ariturk E, Rizalar R, Bernay F. Risk factors influencing inadvertent hypothermia in infants and neonates during anesthesia. Paediatr Anaesth. 2005;15(7):574-579.
14. Holland AJ, Ford WD. The influence of laparoscopic surgery on perioperative heat loss in infants. Pediatr Surg Int. 1998;13(5-6):350-351.
15. Saad S, Minor I, Mohri T, Nagelschmidt M. The clinical impact of warmed insufflation carbon dioxide gas for laparoscopic cholecystectomy. Surg Endosc. 2000;14(9):787-790.
16. Dean M, Ramsay R, Heriot A, Mackay J, Hiscock R, Lynch AC. Warmed, humidified CO2 insufflation benefits intraoperative core temperature during laparoscopic surgery: A meta-analysis. Asian J Endosc Surg. 2017;10(2):128-136.
17. Cheong JY, Keshava A, Witting P, Young CJ. Effects of Intraoperative Insufflation With Warmed, Humidified CO2 during Abdominal Surgery: A Review. Ann Coloproctol. 2018;34(3):125-137.
18. Birch DW, Dang JT, Switzer NJ, et al. Heated insufflation with or without humidification for laparoscopic abdominal surgery. Cochrane Database Syst Rev. 2016;10(10):CD007821.
19. Journeaux M. Peri-operative hypothermia: implications for practice. Nurs Stand. 2013;27(45):33-38.
20. Burns SM, Wojnakowski M, Piotrowski K, Caraffa G. Unintentional hypothermia: implications for perianesthesia nurses. J Perianesth Nurs. 2009;24(3): 167-173.
21. Sessler DI. Temperature monitoring: the consequences and prevention of mild perioperative hypothermia. South. African J. Anaesth. Analg. 2014;20(1):25-31.