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저체온 환자 치료에서 정맥주입 수액의 열손실을 막는 간단한 방법에 관한 고찰

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- Abstract -

A Simple and Easy Method to Prevent Intravenous Fluid Heat Loss in Hypothermia

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Purpose: For the treat hypothermia patients, active warming might be needed. In most emergency departments, IV warm saline infusion is used for treatments. However, during IV warm saline infusion, heat loss from the warm saline may occur and aggravate hypothermia. Thus, in this study, we conducted an experiment on conserving heat loss from warm saline by using a simple method.

Methods: Four insulation methods were used for this study. 1) wrapping the set tube for the administration of the IV fluid with a cotton bandage, 2) wrapping the set tube for the administration of the IV fluid with a cotton bandage with aluminum foil, 3) wrapping the warm saline bag and tube with a cotton bandage, and 4) wrapping the warm saline bag and tube with a cotton bandage with aluminum foil. Intravenous fluid was preheated to a temperature between 38-40°C. The temperatures of the saline bag temperature and the distal end of the IV administration set were measured every ten minutes for an hour. The infusion rate was 1000 cc/hr, and to obtain an accurate infusion rate, we used an infusion pump.

Results: The mean initial temperature of the saline bag was 39.11°C. An hour later, the fluid temperature at the distal end of the fluid temperature ranged from 29.63°C to 34.3°C. Without any insulation, the initial temperature of the pre-heated warm saline, 39° had decreased to 34.8°C after having been run through the 170-cm-long IV administration tube, and after 1-hour, the temperature was 29.63°C. As we expected, heat loss was prevented most by wrapping both the saline bag and the IV administration set with a cotton bandage and aluminum foil.

Conclusion: Wrapping both the saline bag and the IV administration set with a cotton bandage and aluminum foil can prevent heat loss during IV infusion in Emergency departments.

Key Words: Hypothermia, Rewarming technique, Resuscitation, Heat loss

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I. Introduction

Hypothermia occurs in a cold environment and often occurs in trauma patients(1) or perioperative patients.(2) In trauma patients, hypothermia, metabolic acidosis, and coagulopathy are a lethal triad of mortality, and hypothermia is an independent factor that increases mortality.(3) Trauma patients require large volumes of rapidly infused intravenous (IV) fluid,(4) therefore, hypothermia may develop quickly during transfer or in the emergency department (ED) if the patient is uncovered and undergoes rapid administration of fluids or blood. Patients suffering from hypothermia are classically treated with passive or active re-warming, and the choice of treatment depends on the severity of the hypothermia.(5) Cardiopulmonary bypass or peritoneal lavage sets are uncommon in the ED; thus, there are some active re-warming methods such as level 1 fluid warmers, thermal jackets, and K-thermia pads, but many hospitals do not have these active warming kits. In contrast, warm saline can be readily accessed in any ED or in a pre-hospital setting. Intravenous (IV) fluid can be warmed in many ways, but heat loss of warmed fluid during infusion is a problem.(6,7) If the infused fluid temperature is under the body temperature, the hypothermia could be aggravated.

The aim of this study was to assess the effect of four different insulation techniques on heat loss occurring from IV fluid administration set tubing and the bag during infusion of warmed IV fluid at a rapid flow rate. We hypothesised that all four techniques would result in a significant decrease in heat loss. Furthermore, we conducted another experiment which adjust the flow rate. The aim of this experiment was to reveal the relationship between the flow rate of the fluid and the heat loss of the fluid.

II. Materials and Methods

1. Design and settings

This study was performed during January 2013 and the area of the resuscitation room was 22.58 m^2. At the time we performed this study, the ambient temperature of the room was 26.5°C and humidity was 10%.

We used the four techniques. (1) Wrapping IV fluid administration set tube with a cotton bandage, (2) Wrapping IV fluid administration set tube with a cotton with aluminium foil, (3) wrapping warm saline bag and tube with a cotton bandage, (4) Wrapping warm saline bag and tube with a cotton bandage with aluminium foil. For comparison, preheated saline bag and IV administration tube set was wrapped neither roll cotton nor aluminium foil. As recommended by ATLS(Advanced Trauma Life Support)(8) for patients, the intravenous fluid was preheated by microwave to 37~40°C. A 1000 ml bag of 0.9% normal saline was used with a 20-drop/ml IV fluid administration set and a tube length of 170 cm. A 30-mm 18-gauge IV catheter was used with the fluid administration set. A digital K-type thermometer was used for temperature measurements. We utilised a Terufusion infusion pump (Terumo Europe, Ltd.) to achieve an accurate infusion rate.

We also used compression bag to increase flow rate. We used same saline, IV administration fluid set, and 18-gauge needle as we used other study.

2. Data collection

We injected the thermosensor probe into the saline bag via the injection port. The probe was located about 3 cm above the injection port because the length of injection port, which we used was 3 cm (Fig. 1), and another thermosensor probe was located at the just distal end of the IV set. The thermosensor probe did not show a difference of less than 0.3°C after 60 second (Fig. 2).

Initial bag temperature was measured immediately after the experiment started. Distal end temperature was measured about 1 minute after the experiment started, because about 16 ml of fluid was needed to initially fill the IV administration set. Temperature was recorded from each probe (saline bag and the distal end) every 10 minute.

We conducted five experiments, and each experiment contained 10 cases. We wrapped the IV administration set from immediately below the chamber to the distal end. The bandage which width is 0.2 cm,

was wrapped around the IV administration set and overlapped once about each half width per turn. The heat conductivity of roll cotton is 0.03 kcal/˚C. As we overlapping the bandage, the heat conductivity is increasing twice per turn. We wrapped from the top of the saline bag to the IV administration set chamber with same method. Commercial aluminium foil was also used to wrap, which width was 150 ㎛, the IV administration set and saline bag. The conductivity of aluminium foil was 196 kcal/˚C. The saline bag and infusion set were hung on a 2 meter high stand, and the infusion pump was attached.

3. Statistical Analysis

We used a two-way analysis of variance to analyse the data with the SPSS software (SPSS 19.0, Inc. Chicago, IL, USA). A p-value <0.05 was considered to indicate statistical significance. We used Scheffe method for post hoc test.

Fig. 1. The saline bag and IV administration tube set with infusion pump.
* : The injection port of saline bag (length 3 cm)
** : Infusion pump which we used for accurate infusion rate
*** : The distal end of IV administration set
The saline bag and IV administration tube set was setting at emergency room. In experiment, saline bag and IV administration tube set was wrapping by roll cotton and aluminium foil. Injection port of saline bag was about 3 cm. Thus, digital thermometer probe was injected into saline bag and the probe was located 3 cm above the injection port hole.

III. Results

The mean temperature of the initial saline bag was 39.8±0.45˚C. Without any insulation, the preheated 39˚C warm saline decreased to 34.8˚C after passing through the IV administration tube.

The mean temperatures of the saline bag for all five groups over time are shown in Fig. 3. Compared with the control group, wrapping the IV administration set alone resulted in similar heat loss in the saline bag. After 30 min, the temperature of the control group and the group in which the IV administration set was wrapped decreased below body temperature 36.5˚C. However, wrapping both the saline bag and IV administration set together with a cotton bandage and aluminium foil maintained temperature above the human body for up to 60 minute. Comparing control group and wrapping saline bag and IV administration set with cotton bandage and aluminium foil, heat loss of saline bag had significant statistically difference (p-value<0.05). We use Scheffe method for post hoc test which showed significant difference.

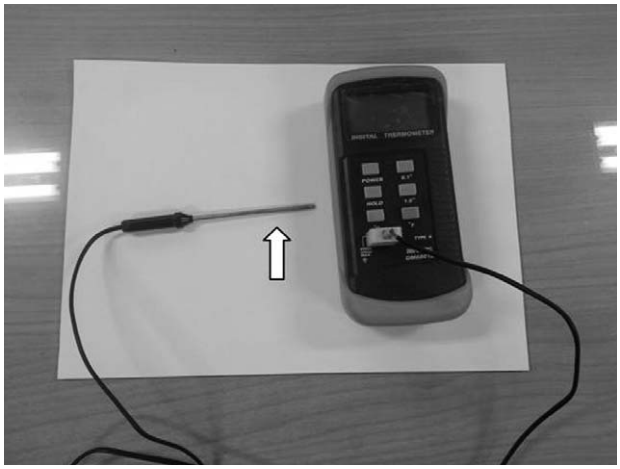

Fig. 2. A digital K-type thermometer and the probe we used. Arrow indicate the probe sensor of the thermometer. It was injected into the saline bag via injection port and at the same time, same digital thermometer was used to detect the temperature of distal end of IV administration tube set.

The mean temperatures at the distal end of the IV administration set for all five groups by time are shown in Fig. 4. Wrapping the IV administration set was effective for 10 minute, but the temperature became sub-therapeutic after 20 minute. Wrapping both the saline bag and IV administration set resulted in a sub-therapeutic temperature at 40 min (Fig. 4). Comparing each group and control group, each group showed significant difference (p-value<0.05). Also comparing wrapping IV administration tube alone group and wrapping both saline bag and IV administration tube by roll cotton and aluminium foil showed significant difference (p-value<0.05). We also compared wrapping both saline bag and IV administration tube by roll cotton group and wrapping both saline bag and IV administration tube by roll cotton and aluminium foil group, it showed siginificant difference, too (p-value<0.05). We used Scheffe method for post hoc test which showed statistically difference.

When we used the flow rate, the temperature of the saline bag and distal end of IV administration set showed no significant change (Fig. 5).

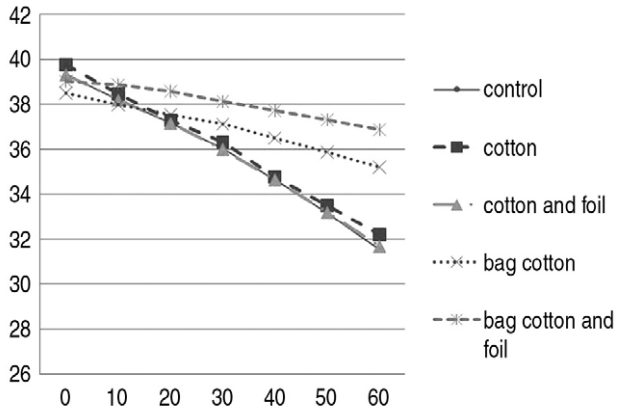

Fig. 3. The mean temperatures of the saline bag for all five groups over times. The temperature of saline bag was recorded every ten minutes. Each dot show the mean temperature of saline bag at every ten minutes with standard deviation. For post-hoc test, we used Schffe method and it showed wrapping both saline bag and IV administration tube was significant difference compared with control group.

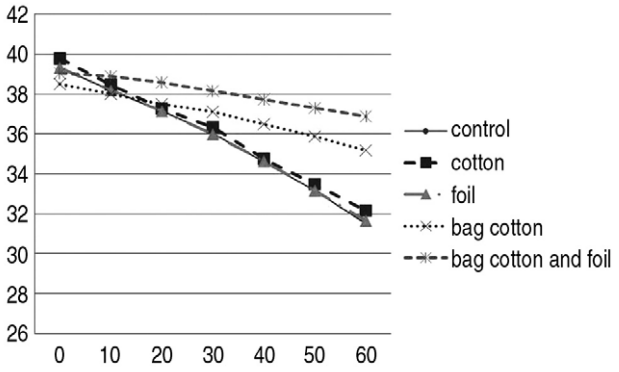

Fig. 4. The mean temperatures at the distal end of the IV administration set for all five groups by times. The temperature of distal end of IV administration tube set was recorded every ten minutes. Each dot show the mean temperature of saline bag at every ten minutes with standard deviation. For post-hoc test, we used Schffe method and it showed wrapping both saline bag and IV administration tube was significant difference compared with control group.

IV. Discussion

Most authorities recommend administration of pre-warmed intravenous fluids for trauma resuscitation and to manage hypothermia. Depending on the degree of hypothermia, peritoneal lavage, bladder lavage, and even cardiopulmonary bypass, may be utilised to raise the patient's core temperature. However, no active re-warming sets such as a peritoneal lavage kit, cardiopulmonary bypass, level 1 fluid warmer,(11) thermal jacket,(12) or K-termia pad are available in most EDs. Therefore, warming the IV saline infusion fluid is commonly used in most EDs and pre-hospital settings.(5) Each liter of fluid delivered to a patient below body temperature induces an energy burden of 1 kcal/˚C for each

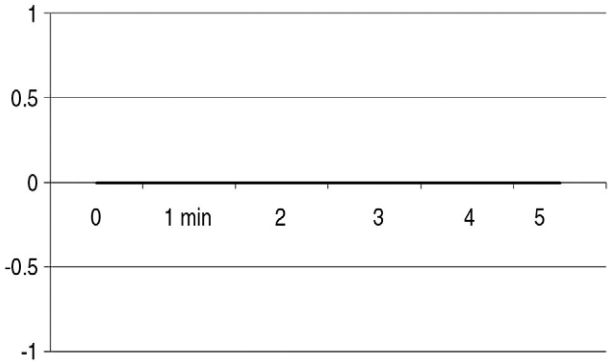

Fig. 5. The mean difference of temperature between the saline bag and the IV administration set when increase the flow rate. The temperature was recorded every 1 minute. It showed no change of temperature as time goes.

degree below the body temperature. Thus, an average adult would have to expend 14 kcal of energy to compensate for 1 L of fluid delivered at 23°C or room temperature. This amount of energy accounts for about 15% of the hourly basal metabolic rate. Without any heat-conserving technique, our data showed that the initial fluid temperature was sub-therapeutic and lower than human body temperature. Wrapping the IV administration set alone resulted in a sub-therapeutic temperature about 10 minute later, and the infused fluid temperature was lower than body temperature after 20 minute. Wrapping both the saline bag and IV administration tube resulted in maintenance of temperature longer than that of the other techniques, but it was sub-therapeutic after 30 minute and lower than body temperature after 40 minute. Most of patients, especially in trauma patients, IV fluid infusion without any insulation may cause hypothermia. Even if we use preheated warm saline by 40°C, without any insulation , the infused fluid temperature actually lower than body temperature.

The length of the IV administration set and the flow rate for all experiments were equal. Therefore, the results may have been due to the exposed surface area of the IV administration set and saline bag. Some studies have reported effective methods of conserving heat during active re-warming(6,7) such as raising the pre-heated saline temperature to 60°C,(9) shortening the IV administration tube set(10) or using warming kits during infusion (K-thermia, thermal jacket, etc). Normal saline is not the only fluid choice for resuscitation. Blood, dextrose, or protein-containing fluid may also be needed in trauma patients. Preheating fluid to more than 43°C may result in protein destruction. In case of using preheated saline temperature to 60°C, the infused fluid temperature may remain above 43°C. Thus, raising the pre-heating temperature is not an appropriate method. Shortening the IV tube is not effective in an emergency situation. Theoretically, this may be useful method in intensive care or operating room setting, where a patient may be stable and not highly active. But when we resuscitate a patient, the IV administration set tube extension length is usually longer than 170 cm (same IV administration tube set as used here) especially the blood transfusion set. IV administration set of the blood transfusion set is usually longer than 170 cm. It may aggravate heat loss of infusion fluid. On the other hand, fluid infusion rate may affect the heat loss of fluid if we using same IV administration set. Thus, using larger bore needle or raising infusion rate can be reducing heat loss of the fluid. For example, K-thermia or level 1 fluid warmer may minimize heat loss of the infused fluid. In fact, we performed other study to evaluate the heat loss of the fluid when we use compression bag. The compression bag was used in same condition. We conducted the experiment using wrapping both saline bag and IV administration tube with roll cotton and aluminium foil. 1L saline was infused in 5 minutes. The result showed, when we increase the IV fluid flow rate, there was no fluid heat loss in 5 minutes (Fig. 5). Our study showed simple method can prevent heat loss of the infused fluid. It also indicated rasing fluid flow rate can be effective to prevent fluid heat loss. But in pre hospital settings or in emergency room, K-thermia or level 1 fluid warmer is difficult to set rapidly. In addition, it is more expensive than roll cotton and aluminium foil. Thus, not every hospital has that equipment.

Furthermore, the fluid volume is smaller and fluid the flow rate is lower in paediatric trauma patients than in adults. Thus, use of a warm IV saline infusion with no insulation can worsen hypothermia, metabolic acidosis, and coagulopathy in paediatric trauma patients.

Our study has few limitations. In this study, we use preheated saline temperature to 38~40°C. For heating saline bag, we use microwave for 2 minute.(13) The temperature of saline bag might depend on saline bag's position or electricity of microwave. Thus, we can't match the temperature of fluid equally. In addition, we use IV administration set for infusion fluid, but when we resuscitate the patients, we usually use IV administration set and extension set for other medication or fluid. So we cannot predict precisely when we resuscitate the patients in emergent situation. Furthermore, further study can be possible. First, as we discussed above, raising infusion rate may reduce heat loss of infused

fluid. Second, if we use 500 cc saline bag also reduce heat loss of infused fluid, because it can reduce surface of saline bag and shortening the time of infusion.

V. Conculsion

In this study, we prevented heat loss during intravenous warm saline infusion using our method. The insulation methods used are readily available and inexpensive in any emergency hospital or prehospital setting.

The temperature of saline must be maintained by any means to treat hypothermia patients.(4,8) However, raising the temperature of the saline, shortening the IV set length, or using active rewarming kits are not effective in many cases. Our results suggest that the simple method of wrapping both the saline bag and IV administration set with a cotton bandage and aluminium foil can prevent heat loss during resuscitation of hypothermic patients.

Many studies have reported that maintaining the temperature of saline is important.(6,10) Our results indicate that wrapping the IV administration set alone cannot maintain the temperature of saline sufficiently. This is the first study to show that wrapping both the saline bag and IV administration set is effective in terms of maintaining the temperature of IV fluid.

We suggest preparing a wrapped set or using a commercial wrapping kit so that patients can be treated rapidly in an emergency situation.

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