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Original Article

Pressure Changes During Layer Cupping in a Skin Model

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ABSTRACT

Background: Cupping is widely used in Korean medicine, but there is a risk of bacterial infection if the suction pump (used for inducing negative pressure) and the patients' skin are not separated. This study aimed to investigate the effect of layer cupping by comparing the pressure changes between layer cupping and conventional cupping.
Methods: To evaluate pressure changes the study was designed with 3 types of conditions applied to a skin model: (1) a Dongbang cup with a manual or motor suction pump (conventional cupping); (2) layer cupping with 2 Dongbang cups; and (3) layer cupping with a cup made by 3D printing and a Dongbang cup.
Results: When a manual suction pump was used (conventional cupping), the pressure did not decrease steadily, and in 1 section there was an increase in pressure. When layer cupping was used, the pressure in the lower cup (which would be directly applied to the patient's skin), decreased steadily.
Conclusion: In the pressure change graph for layer cupping in this skin model, the pressure in the lower cup (which would be placed on the patient's skin) steadily decreased, and reached equilibrium. Therefore, the layer cupping model may help to reduce the risks of bacterial infection.

Introduction

Cupping is a simple, safe, and effective treatment that has been practiced for thousands of years [1]. Cupping refers to a method of treating a condition/disease with physical stimulation that is created by negative pressure inside a cup using a heating or negative pressure device [2]. There are 2 general forms of cupping; dry and wet cupping. In dry cupping, only negative pressure is applied. In wet cupping, the skin under the cup is pricked with a needle and the blood is sucked into the cup [3].

Cupping therapy is commonly used for various conditions/diseases in the field of Korean medicine and has been covered by the Korean National Health Insurance since 1987 [4]. A survey by the Ministry of Health and Welfare in 2017, reported that 53% of patients who used Korean medicine received cupping, which placed cupping as the 2nd most popular treatment after acupuncture [5].

Various cupping devices are currently in use. Among them, exhaust type cupping is popular because it can be used safely without the use of fire. For this type of cupping, the suction pump is connected to the cupping valve, and the air inside the cup is removed by the pump, which creates a negative pressure [1]. This allows airflow to occur between the suction pump and the cup. However, this process can lead to unexpected infections. For instance, the suction pump for inducing negative pressure is generally used multiple times causing a risk of bacterial infection because the suction pump and the patient's skin are not completely separated [6]. The device may be contaminated and must be sterilized before reuse to allay fears over the possibility of pathogen transmission through cupping devices [7,8]. Pathogenic microbes including methylobacteriaceae were isolated from used manual suction pumps collected from private hospitals and university hospitals [9]. Therefore, a suction pump which is used multiple times may cause the spread of infection through air exchange [9].

In a survey on the use of cupping devices by Korean medicine doctors (KMDs) in 2008, 95.8% of respondents said that they used a manual suction pump [10]. As most KMDs in clinical practice use manual suction pumps, it is necessary to examine

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ways to prevent the spread of infection. One way to do this is the development of a cupping device that can prevent bacterial infection due to indirect contact between the manual suction pump and cup.

Owing to the prevalent use of cupping therapy, studies have been conducted on the pressure attained during cupping therapy. For instance, a study reported the risk of pressure dropping out during cupping by evaluating pressure during bloodletting cupping therapy [11], and a systematic review reported literature describing the negative pressure levels in cupping therapy [12]. However, there is a scarcity of research in this field.

In this study, the conventional cupping method was compared with the layer cupping method where 2 cups are stacked. The layer cupping method can prevent bacterial infection and patients may be more comfortable during treatment [13]. Layer cupping is a new cupping therapy method designed by Gi Young Yang in which 2 or more cups overlap. The negative pressure generated by pumping the 1st cup (on top) is transmitted to the inside of the 2nd cup (underneath), which has a pressure control cap at the bottom and is operated at set intervals of time [13]. The effects of layer cupping will be determined in this study, and we expect to use the results in clinical practice.

Materials and Methods

Materials

This study was conducted using exhaust type cupping. The Dongbang cup (Dongbang No. 1, DONGBANG MEDICAL, Boryeong, Korea) which consists of a control cap with a 0.3 mm diameter hole under the valve that gradually equilibrates the pressure in the upper and lower cup during the layer cupping therapy, and a clear resin (RS-F2-GPCL-04, Formlabs, Somerville, USA) cup produced by a 3D printer (Form3, Formlabs, Somerville, USA) were used (Fig. 1). The volume of each cup was set according to the experimental conditions, and the volumes are shown in Table 1 (data is the average value of 5 measurements). The volume was measured using 95% ethanol.

To measure the change in pressure during exhaust type cupping, a skin model similar to the human body was produced. The skin model used in this study was a modified 3 mm thick silicon plate model. Briefly, a section of 20 mm nitrile butadiene rubber was added under the existing 3 mm silicon plate to mitigate the impact that occurs during the cupping attachment process. During the measurement process, acrylic (360 × 360 × 10 mm) was applied to the top and bottom of the silicone plate and nitrile butadiene rubber to enhance the stability of the skin model. Drilled holes on the bottom of the combined skin model were used for a 7 mm outer diameter pipe, and a silicone tube (inner diameter 5.84 mm, outer diameter 9.98 mm) with 2 types of digital manometer: (1) Tpi665 (SUMMIT, Incheon, Korea) and (2) WL103P (KoreaDigital, Hwasun, Korea) which were used to measure the pressure change inside the cups. In the layer cupping experiment, the cups were directly connected to a digital manometer using a pipe and silicone tube to measure the pressure change inside the cup (Figs. 2 and 3). Airtightness was determined by testing whether the pressure retention performance of each cupping device could be maintained at 90% or more of the maximum pressure for 10 minutes according to Korean Industrial Standards P International Organization for Standardization. The pressure measurements in this study were made using digital manometer 1 and digital manometer 2, depending on the purpose. For the determination of airtightness, calibration was performed at an accredited calibration institution using digital manometer 1 which has more precise resolution. However, digital manometer 1 recorded the change in pressure every second, such that the change in pressure could not be observed in detail. Digital manometer 2 was a pressure gauge which allowed change to be observed every 0.2 seconds. Consequently, digital manometer 2 was used to measure the pressure change inside the cup. The specifications of the digital manometers are listed in Table 2. Adhesives (SUPER XG, CEMEDINE, Tokyo, Japan) were used to maintain airtightness between the skin model and silicone tube along with the cup and the silicone tube.

To pump the cup, a manual suction pump (DB302, DONGBANG MEDICAL, Boryeong, Korea) and a motor suction pump (Motor Suction Pump, HANSOL MEDICAL CO., Paju, Korea) were used (Fig. 4).

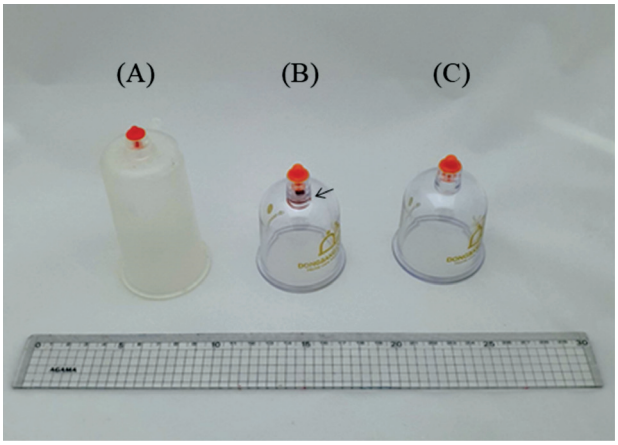

Fig. 1. Types of cups. (A) Cup made by 3D printing. (B) Dongbang cup no. 1 with pressure control cap. (C) Dongbang cup no. 1 without pressure control cap.

Table 1. Volumes According to the Types of Cups.

	Dongbang cup	Between 2 Dongbang cups	Between a Dongbang cup and a cup made by 3D printing
Volume (mL)	81.36 ± 1.60	68.84 ± 1.15	78.80 ± 1.30

Data are presented as mean ± SD.

Fig. 2. Skin model with digital manometer and layer cupping with 2 Dongbang cups.

Fig. 3. Skin model with digital manometer and layer cupping with a Dongbang cup and a cup made by 3D printing.

Table 2. Specification of Digital Manometers.

	Digital manometer 1	Digital manometer 2
Measurement range (hPa)	-7,000–7,000	-1,000–3,000
Resolution (hPa)	0.1	0.244
Measurement cycle (s)	1	0.2

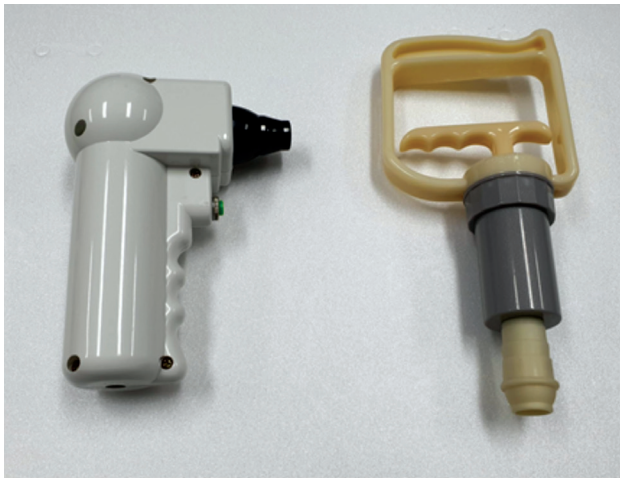

Fig. 4. Motor suction pump and manual suction pump.

Procedure and methods

Given that temperature and humidity can affect the experimental results, direct sunlight was excluded to improve the measurement conditions in the laboratory; a temperature of 25 ± 5°C and a humidity of 40 ± 10% were maintained.

In the 1st trial, 1 Dongbang cup was placed on the skin model and pumped using a motor suction pump to measure the pressure change pattern. Additionally, manual suction pumping was used with the same cup until it reached an approximate value of the negative pressure obtained by the motor suction pump, and the number of pumps and changes in pressure were recorded.

In the 2nd trial, 2 cups were stacked and then manually pumped as many times as in the 1st trial using a manual suction pump, and pressure change in the upper and lower cups was recorded. Since the same cups were overlaid, the volume of the upper cup was relatively smaller than that of the lower cup.

In the 3rd trial, a Dongbang cup was placed at the bottom and the cup made by 3D printing was placed on top, the ratio of the inner volume of the upper and lower cups was close to 1:1. Then, the approximate value of the negative pressure obtained in the 1st trial was reached using a manual suction pump. Pumping was manually performed, and the pressure change in the upper and lower cups

was measured.

The 2nd and 3rd trials represented the layer cupping model. As shown in Fig. 5, 2 cups were overlapping.

For all trials, using digital manometer 2, the internal pressure of the cups was measured at 0.2-second increments until equilibrium had been reached.

Results

Pressure changes in conventional cupping

The following results were confirmed by measuring the change in pressure using a motor suction pump for Dongbang cupping. The minimum pressure during cupping was -690.2 hPa and the pressure showed a steadily decreasing pattern. When pumping with a manual suction pump, the minimum pressure for cupping was -663.5 hPa using 5 pumps. It was observed that the pressure did not decrease steadily, and showed an increase in pressure in 1 section. The graphs of pressure change over time, when the motor suction pump was used, and the manual suction pump was used, are shown in Figs. 6 and 7, respectively.

Pressure changes in layer cupping with 2 identical Dongbang cups

After the Dongbang cup overlapped with another Dongbang cup, the pressure changes (using a manual suction pump) in the upper and lower cups were measured. The lowest pressure in the upper cup was -651.4 hPa during 5 manual pumps. The pressure did not decrease steadily and increased in a specific section, as in the manual pumping results in the previous trial. The pressure changed in the upper and lower cups as it moved towards equilibrium with time. In the case of the pressure change in the lower cup (which would be directly applied to the skin), a steadily decreasing pattern was observed when the cup was pumped using a motor suction pump as in the previous trial. When equilibrium was achieved, the pressure was -324 hPa for the upper cup and -322 hPa for the lower cup. The pressure change over time is shown in Fig. 8. In this trial, the volume of the upper cup was smaller than in the lower cup.

Pressure changes in layer cupping with a cup made by 3D printing

After the cup made by the 3D printing was overlaid on top of the Dongbang cup, the pressure changes in the upper and lower cup were measured using a manual suction pump. The lowest pressure

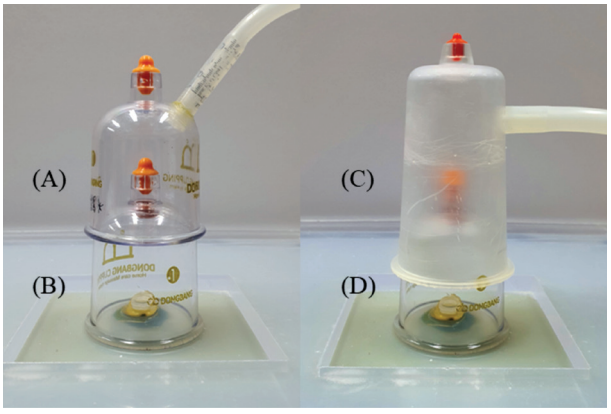

Fig. 5. Layer cupping model. (A) Upper cup, Dongbang cup no. 1. (B) Lower cup, Dongbang cup no. 1. (C) Upper cup, Cup made by 3D printing. (D) Lower cup, Dongbang cup no. 1.

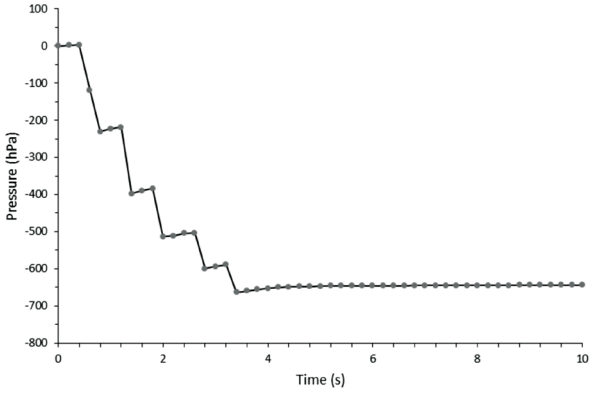

Fig. 7. Pressure changes in conventional cupping with a manual suction pump.

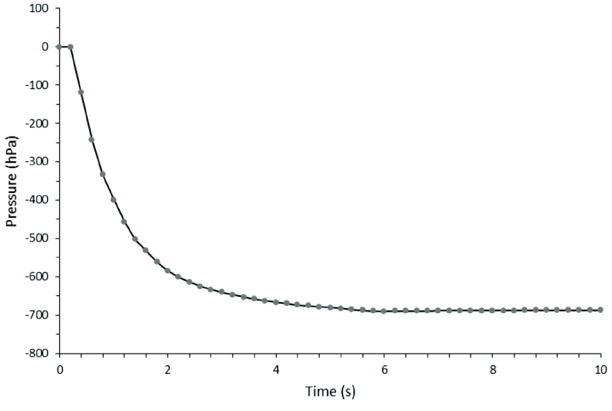

Fig. 6. Pressure changes in conventional cupping with a motor suction pump.

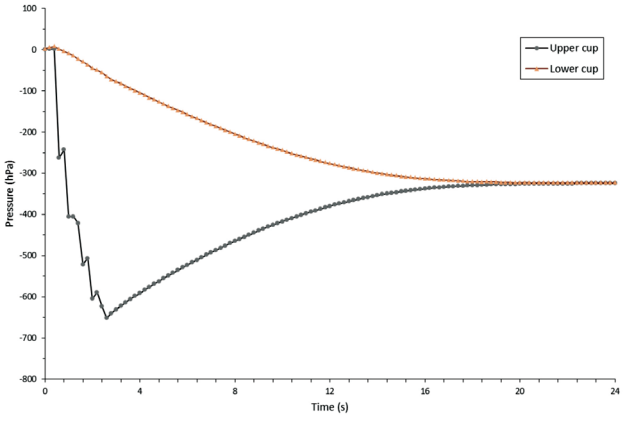

Fig. 8. Pressure changes in layer cupping with 2 Dongbang cups.

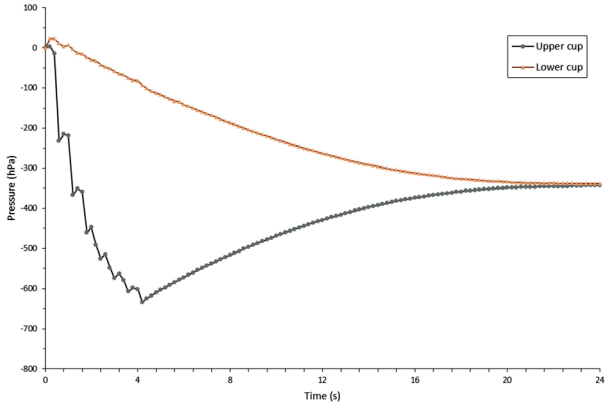

Fig. 9. Pressure changes in layer cupping with a Dongbang cup and a cup made by 3D printing.

in the upper cup was -633.6 hPa after 7 manual pumps. It was observed that the change in pressure did not decrease steadily but increased in a specific section, as in the manual pumping results in the previous trial. The pressure in the upper and lower cups changed towards equilibrium with time. In the case of the pressure change in the lower cup (which would be directly applied to the skin), it was observed that it showed a steadily decreasing pattern when pumped using a motor suction pump as in the previous trial. When equilibrium had been achieved, the pressure was -341 hPa for the upper cup and -339 hPa for the lower cup. The pressure change over time is shown in Fig. 9. In this trial, the volume ratio of the upper cup and the lower cup was about 1:1.

Discussion

A survey of KMDs in 2008 observed that 77% of the respondents answered that infection caused by wet cupping was a side effect of cupping [4]. It is essential to prevent infection caused by cupping. In 2019, 784 KMDs were surveyed regarding the perception and performance of infection prevention and management, and the number of participants who knew that infection cases may be related to Korean medical treatment was low at 15%. In addition, the number of participants who knew the disinfection guidelines of the Ministry of Health and Welfare was as low as 24.5%. Moreover, the number of participants who had not received infection control education was high at 41.1% [14]. Despite the importance and an increase in social demand for infection control, there is a relative lack of interest and education regarding infection control by KMDs. Therefore, studies related to this field are needed.

Considering the risk of bacterial infection during the process of using a manual suction pump for cupping therapy, a cupping device that can prevent bacterial infections caused by indirect contact with the manual suction pump was developed in this study. The pressure change was measured using a manual and motor suction pump for conventional cupping, and a trial was conducted to measure the pressure change that occurred whilst using a manual suction pump in layer cupping.

From the results of the 1st trial regarding pressure changes in conventional cupping, the pressure inside the cup decreased steadily when the motor suction pump was used for conventional cupping, and a positive pressure section was observed when a manual suction pump was used. This was because the air from the manual suction pump moved into the cup, which in turn can increase the risk of bacterial infection. To solve this problem, a layer cupping model was designed and studied, and the effect of using a motor suction pump was determined as shown in the results for 2nd and 3rd trials. When a manual suction pump was used for layer cupping, a positive pressure section was observed in the pressure graph for the upper cup, but the lower cup, which would be on the patients' skin, showed a steadily decreasing pressure which was similar to that observed when using a motor suction pump. In other words, the air moved only from the lower cup to the upper cup, and bacterial infection that may be caused by the manual suction pump was not subsequently observed.

From the results of 2nd trial concerning pressure changes in layer cupping with 2 identical Dongbang cups, and the 3rd trial involving pressure changes in layer cupping with a cup made by 3D printing, when the equilibrium pressure was achieved, the lower cup was maintained at 2 hPa higher than the upper cup. The pressure inside the upper and lower cup was balanced as the air in the lower cup moved to the upper cup. It is assumed that when the pressure difference between the upper and lower cups becomes small, the force of air passing through the upper cupping valve becomes insufficient, such that the air can no longer pass and is in equilibrium. In the 2nd trial, layer cupping was conducted with the same Dongbang cup above and below. In this case, when the minimum pressure in the upper cup was -651.4 hPa, the equilibrium pressure of the lower cup that would be on the patient's skin was -322 hPa. To obtain a greater negative pressure for the procedure, it would be beneficial if the volume of the cup was larger. Therefore, in the 3rd trial the volume of the upper and lower cups was adjusted to 1:1 with the cups made by 3D printing in which the volume of the upper cup was enlarged. With the increased volume of the upper cup, the number of pumps was required to be increased twice to match the minimum pressure of the upper cup [15]. Therefore, when the minimum pressure of the upper cup was -633.6 hPa, the equilibrium pressure of the lower cup, which was applied to the patient's skin was -339 hPa. Therefore, if the volume ratio of the upper cup and the lower cup is more than 1:1, the negative pressure of the lower cup will increase. Through both trials, the treatment pressure ranged from -322hPa to -339hPa. The negative pressure in this range was determined to be a valid negative pressure with therapeutic effects [12,16]. To obtain a greater negative pressure, a further increase in the volume of the upper cup can be applied as determined in the 3rd trial.

Use of a disposable sterilization cupping device can prevent bacterial infection being transferred from the suction pump [6], but it is not often used in clinical practice because it is cumbersome. Conversely, the layer cupping model can easily prevent the transfer of bacterial infection that may be caused by indirect contact with the manual suction pump because of the layering of an additional cup, and is not too cumbersome. The layer cupping can also be utilized in both dry and wet cupping because it only changed the method negative pressure is applied. In addition, layer cupping operated using pressure change presented on a graph allows the KMD to infer the sensations which may be delivered to the patient whilst receiving the cupping therapy. In the case of using a manual suction pump, pressure has been reported to decrease rapidly in approximately 0.5 seconds by around 200 hPa during pumping, and the patient may feel discomfort in the treatment area [15]. If cupping therapy is misused and performed with a high negative pressure, blisters are likely to occur [17]. In contrast, in layer cupping therapy, even if the highest negative pressure is applied to the upper cup, a low negative pressure is applied to the lower cup, and the internal pressure inside the cup

decreases relatively gradually. This enables the patient to undergo cupping therapy comfortably.

In this study using a skin model, the sensations a patient may feel during cupping were inferred from the pressure change observed on the graph, but it is necessary to compare the feeling of discomfort during treatment by performing conventional cupping and layer cupping on patients in a follow-up study.

According to the Korean Industrial Standards P International Organization for Standardization, the process of cupping was conducted by measuring the maintenance of the pressure inside the cup, but the skin model is limited because it lacks the body hair and pores that exist in actual skin. Therefore, it is necessary to determine the effectiveness of the layer cupping model through follow-up studies on various patients of different ages, sex, and skin conditions. Additionally, further study on the treatment pressure delivered using various volumes of upper cups is needed to ascertain the optimal treatment pressure delivered by varying the ratio of the volume of the lower and upper cups.

Conclusion

Indirect contact with the manual suction pump can be a possible cause of the spread of bacterial infection during cupping therapy. Therefore, this study was conducted to develop a method to prevent the risk of infection, and meaningful results were obtained through the layer cupping model. In the pressure change graph for layer cupping, the pressure in the lower cup (which would be placed on the patient) steadily decreased and reached equilibrium. Therefore, if a layer cupping model was used when cupping with a manual suction pump, this may help to prevent bacterial infections. The results of this study can serve as the basis for subsequent studies on cupping therapy and prevention of bacterial infections, with the hope that future studies will deliver standardization of layer cupping.

Conflicts of Interest

Gi Young Yang has been the editor of Journal of Acupuncture Research since 2017, but had no role in the decision to publish this original article. No other potential conflict of interest relevant to this article was reported.

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