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Comparative analysis of the effectiveness of blood cleaning devices versus traditional methods in treating skin contaminated with blood

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Abstract: *This study aims to compare the effectiveness of a blood cleaning device with traditional wet towels in removing blood contamination from skin. Twenty porcine skins were selected as samples and divided into an experimental group and a control group. The experimental group was treated with a blood cleaning device, while the control group was cleaned with a wet towel. The results showed that the qualification rate for blood treatment in the experimental group (62.3%) was significantly higher than that in the control group (34%), with a statistically significant difference (P<0.001). Additionally, the cleaning efficiency of the experimental group (45%) was also significantly higher than that of the control group (18.7%), with a similar statistically significant difference (P<0.001). Furthermore, a user satisfaction survey indicated that 87% of users found the comfort level of the new blood cleaning device to be good, while only 13% of users were satisfied with the traditional method. In conclusion, compared to traditional wet towel wiping, the new blood cleaning device demonstrates higher convenience, speed, and effectiveness in treating blood contamination.*

Keywords: *Blood Cleaning Device, Blood Cleanup, Blood-borne Pathogens, Occupational Exposure*

1. Introduction

With the thriving development of the medical industry, occupational exposure to pathogens in blood has become a severe health threat to healthcare workers (HCWs) worldwide [1]. A study by A. J. Birnie et al. [2]has revealed a concerning phenomenon: in up to 33% of surgical procedures, surgeons experience at least one instance of blood splashing onto their faces, and in 15% of surgeries, assistants also encounter similar situations. The majority of these splashed blood droplets (approximately 80%) are smaller than 0.6 millimeters in diameter, acting like miniature "time bombs" that can lead to severe consequences once they come into contact with the skin. Even more worrying is the blood particulate mist generated by electric medical devices during surgery, which further exacerbates the contamination of facial skin, posing a significant risk to HCWs in the operating room. These minute blood particles are not only difficult to detect but may also carry an astonishing number of pathogens, which, if they enter the body through skin breaks or mucous membranes, can trigger severe infections[3].

Long-term exposure to pathogens in blood poses a significant threat to the health of HCWs. They face a high risk of infection with human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV), and other blood-borne pathogens-related diseases [4]. These diseases not only cause immense damage to the physical health of HCWs but can also have profound impacts on their careers and family lives.

Therefore, how to quickly and effectively clean blood after contamination to reduce the risk of infection has become an urgent problem to be solved. However, in current surgical practices, when blood splashes onto the skin, HCWs often rely solely on wet towels for wiping. Although this method is simple and easy to implement, it is not ideal in terms of effectiveness, making it difficult to thoroughly remove blood and pathogens from the skin. Against this background, this paper aims to explore a new method for blood contamination treatment, with the hope of more effectively removing blood and pathogens from the skin, thereby reducing the risk of infection for HCWs. By comparing and

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analyzing this new method with traditional methods, this paper aims to assess the feasibility, effectiveness, and safety of the new method, providing strong support for future clinical practice.

2. Structure Design and Characteristics of the Blood Cleaning Device

The blood cleaning device primarily consists of components such as a liquid inlet, negative pressure tube, spray tube, waste liquid bottle, and clean water bottle. During clinical surgeries, when healthcare providers' skin becomes stained with blood, the spray tube draws clean water from the clean water bottle through the liquid supply assembly and sprays it onto the bloodstains. The clean water moistens the bloodstains, and then negative pressure suction is applied through the liquid inlet, drawing both the stains and the sprayed water into the negative pressure tube, thereby enhancing the cleaning effect.

3. Materials and Subjects

Twenty pieces of pig skin (20*15cm) from inspected and certified healthy pigs, 80mL of pig blood, towels, clean water, a blood cleaning device, 2mL syringes, and occult blood test cards were selected. The implementation of this research protocol adhered to relevant ethical requirements.

4. Methods

4.1. Experimental Procedure

At an ambient temperature of 25℃, 20 pieces of pig skin were divided into an experimental group (10 pieces) and a control group (10 pieces), the experimental procedure is shown in Figure 1. ① For the experimental group, 30 blood droplet positions were marked sequentially with marking pins (Figure1 A). Using a syringe, 0.1 mL of blood was dripped onto the underside of each marked point for a duration of 15 seconds (Figure1 B). Cleaning was initiated from the 30th blood droplet position using the blood cleansing device, proceeding in reverse order until all droplets were cleaned, with each droplet being treated five times.② For the control area, 30 blood droplet positions were also marked sequentially with marking pins. Using a syringe, 0.1 mL of blood was dripped onto the underside of each marked point for a duration of 15 seconds. Cleaning was then initiated from the 30th blood droplet position using a wet towel, proceeding in reverse order until all droplets were cleaned, with each droplet being treated five times. (Before the experiment, both pieces of porcine skin were soaked in an acidic environment for 2 hours to reduce the influence of original bloodstains on the occult blood test.)

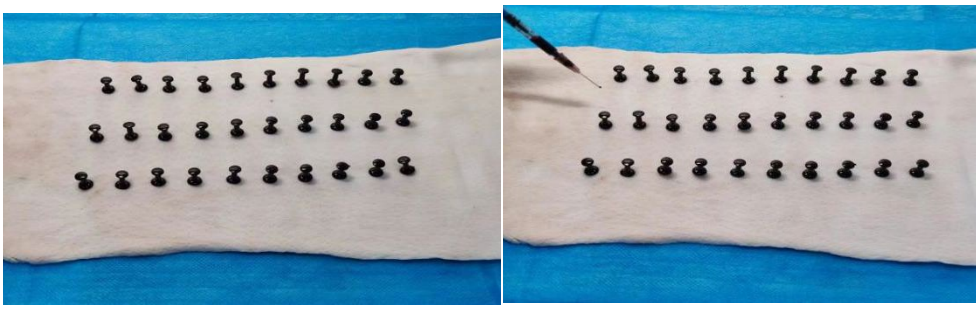
4.2. Data Collection Methods

①Visual Inspection: Observe whether each group meets the criteria.

②Occult Blood Test: Assess the cleanliness of each area.

4.3. Objective evaluation

We conducted a satisfaction survey among 30 users.



A *B*

Figure 1: Experimental Flowchart: In Diagram A, use marking pins to mark the position where the blood droplet is to be placed; in Diagram B, use a syringe to drip the blood below the marked point.

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5. Observation indicators

5.1. Qualification Rate

The experimenter observes the surface of the porcine skin. The presence of any bloodstains is deemed as unqualified, while the absence of any contaminants is deemed as qualified [5].

5.2. Cleanliness Rate

The operator wears clean gloves and applies one drop of reagent A from the occult blood OB test kit onto the blood droplet area. After allowing the reagent to fully penetrate, one drop of reagent B is then applied. The results are interpreted within 2 minutes. After obtaining a positive result, the gloves are changed to avoid interfering with subsequent tests. After adding the color developer B, a positive result is indicated if the area turns violet-blue within 10 seconds. A negative result is indicated if the area turns violet-blue after 10 seconds or remains unchanged [6].

5.3. Degree of satisfaction

Analysis is conducted based on a satisfaction survey developed by the hospital. Satisfaction rate = (number of cases with "satisfied" + "basically satisfied") / total number of cases × 100%.

6. Statistical Methods

Statistical analysis was performed using SPSS 27.0 software. Measurement data are presented as mean ± standard deviation ($\overline{X} \pm S$) and were analyzed using the t-test. For comparisons within groups, analysis of variance with repeated measures design was employed. Count data were analyzed using the χ^2 test. A P-value < 0.05 was considered statistically significant.

7. Results

7.1. Comparison of Visual Inspection Qualification Rates between Two Groups

The comparative study results indicate that the visual inspection qualification rate in the experimental group is 62.3%, while that in the control group is 34%. There is a statistically significant difference between the two groups (p < 0.001). See Table 1 for details.

Table 1: Visual Inspection Qualification Rates

Group	Qualified	Unqualified	Qualification Rate.
Experimental group	187	113	62.3%
Control group	102	198	34%
$\chi 2$		48.232	

7.2. Comparison of Cleanliness Rates between Two Groups

The comparative study results showed that the cleanliness rate in the experimental group was 45%, while the cleanliness rate in the control group was 18.7%, with a statistically significant difference between the two groups (p<0.001). This is presented in Table 2.

Table 2: Cleanliness Rates

Group	Qualified	Unqualified	Cleanliness Rates
Experimental group	135	165	45%
Control group	56	244	18.7%
$\chi 2$		47.935	

7.3. Comparison of User Satisfaction between the Two Methods

The survey results indicated that 87% of users found the comfort level of the new blood cleaning device acceptable, while only 30% of participants deemed the traditional method acceptable. This is

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presented in Table 3.

Table 3: User Satisfaction Degree

Group	n	Satisfied	Basically Satisfied	Dissatisfied,	Overall Satisfaction
Experimental group	30	15(50%)	11(37%)	4(13%)	26(87%)
Control group	30	3(10%)	6(20%)	21(70%)	9(30%)

8. Discussion

Currently, globally, long-term HBV virus infections account for 3.5% of the total population, while in the United States, the number of individuals with chronic HCV virus infections exceeds 3 million. Additionally, the proportion of people suffering from one or more chronic viral infections also exceeds 1%. These alarming figures undoubtedly significantly increase the risk of healthcare workers (HCWs) being exposed to blood-borne pathogens and contracting infections during their work [7, 8, 9]. Furthermore, according to statistical data, the overall morbidity rates among global HCWs due to occupational exposure to blood and bodily fluids are as high as 56.5% and 39.0%, respectively. This not only highlights the high morbidity rates associated with occupational exposure to blood and bodily fluids among HCWs but also has a series of negative psychological impacts on them, such as anxiety, stress, and insomnia [4, 10].

Given this situation, addressing blood splashes onto the skin during surgeries is particularly important. Finding a rapid and effective way to clean up blood splashes and other splashes during surgeries has become a critical issue that needs to be addressed.

This paper aims to explore the differences between a novel blood cleaning device and traditional cleaning methods by comparing and analyzing their performance in terms of blood contamination treatment success rates, cleaning efficiency, and subject satisfaction. By utilizing statistical methods, we can clearly understand the advantages of the novel blood cleaning device over traditional cleaning methods in terms of success rates, cleaning efficiency, and satisfaction.

The blood cleaning device mentioned in this paper employs negative pressure technology to actively adsorb blood and is equipped with a spray pipe to moisturize the skin, thereby achieving a better blood cleaning effect. In contrast, traditional wet towels mainly rely on passive adsorption methods, suffering from issues such as insufficient power and inadequate skin moisturization. Therefore, from this perspective, the novel blood cleaning device undoubtedly has more advantages than traditional blood handling methods.

However, it is worth noting that this experiment also has some limitations. For example, during simulation experiments on pig skin, there may be residual blood that has not been thoroughly cleaned, which could create a false impression of incomplete cleaning and affect the accurate assessment of the experiment's cleaning efficiency. Additionally, the visual inspection method and satisfaction surveys used in this experiment also have certain subjective errors, which may impact the judgment of blood contamination treatment success rates. Therefore, to obtain more accurate and reliable research results, the findings of this experiment still need further research and confirmation.

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