Evaluation of the application effect of 3M adhesive tape for the protection of pressure connectors after arterial puncture placement

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In order to analyze the application effect of 3M adhesive tape in the protection of pressure joints after arterial puncture placement, 120 patients with arterial puncture and tube placement admitted from February 2019 to February 2021 were selected as the study subjects by using the purposive sampling method. They were divided into treatment groups, control group 1 and control group 2 according to the randomized numerical table method, with 60 cases in each group. In control group 1, the pressure transducer connector was placed in direct contact with the skin of patients; in control group 2, a square of medical gauze was placed under the pressure transducer connector. In the treatment group, 2 × 2 cm 3M adhesive tape was placed under the pressure transducer connector. Comparison of the three groups of patients with the pressure transducer and tube placement joints below the skin injury, pain score, catheter displacement, adverse reactions and nursing satisfaction. Our results showed that the incidence of skin pressure injury (22.50%) at the tube placement site, the incidence of catheter displacement (7.50%) and the incidence of adverse reactions (10.00%) were significantly lower in the treatment group than in the control group1 (60.00%, 32.5%, 45%, $P < 0.05$). In particular, 3M tape significantly inhibited the occurrence of stage III-IV pressure injury ($P < 0.05$). The rate of pain relief at the tube placement site and nursing satisfaction in the treatment group were significantly higher than that in control group 1 ($P < 0.05$). Meanwhile, compared with control group 2, the catheter displacement rate and the incidence

of adverse reactions were significantly lower, and nursing satisfaction was higher in the treatment group. However, the incidence of skin pressure injury and pain score results were similar between the treatment group and control group 2. In addition, there were significant differences in the incidence of skin pressure injuries, pain scores, and satisfaction with care in control group 2 compared with control group 1. Although the application of medical gauze was able to reduce skin pressure injuries, relieve pain and improve patient care satisfaction, 3M adhesive tape, in addition to these effects, further prevented the occurrence of catheter displacement and adverse reactions. In conclusion, the use of 3M adhesive tape can effectively prevent pressure injuries, increase patient comfort, avoid catheter displacement, reduce complications, and improve patient care satisfaction.

Keywords. 3M adhesive tape; Effect; Pressure connectors; Arterial puncture placement

1 INTRODUCTION

Studies have shown that arterial catheters are placed in approximately 70% of patients in the intensive care unit (Imbriaco et al., 2022). Arterial catheters are widely used for invasive blood pressure monitoring and blood specimen collection (A. Wang et al., 2020). Invasive arterial blood pressure is important for understanding the patient's condition, guiding the treatment of cardiovascular disease, observing the effect of vasoactive drugs, and safeguarding the patient's life (Palmer et al., 2022). And it is the preferred method for monitoring blood pressure changes in critically ill patients (Ezad & Rawlins, 2022). As the conditions of critically ill patients change rapidly, arterial catheters can provide accurate, reliable and continuous arterial pressure data during resuscitation, which can win valuable time for real-time monitoring and effective resuscitation of patients, and at the same time reduce the pain of repeated puncture and improve work efficiency (Q. Wang et al., 2020; Zwisler et al., 2019). Therefore, arterial puncture catheterization has become a commonly used monitoring tool in medical and nursing practice for critically ill patients. In the process of arterial

puncture and tube placement, the following problems exist: (1) The skin at the pressure connector is directly and continuously pressurized, which is prone to pressure damage. (2) The small gauze pad at the pressure connector can easily cause extubation when changing the medication again. Currently, most arterial catheters are fixed only with tension-free fixation patches (Frota et al., 2023). Improper fixation can lead to decannulation, catheter kinking, and catheter torsion (Jia et al., 2021). The use of strong and sturdy fixation to prevent decannulation leads to problems such as redness, swelling, and ulceration of the skin at the puncture site as well as at the connection site of the pressure transducer during extubation, which seriously affects the patient's prognosis.

With the development of clinical medicine and the aging of China's population, there are more and more critically ill patients and patients undergoing major surgeries in the hospital population. In recent years, arterial puncture catheterization has been widely used in the operating room for invasive blood pressure monitoring, multiple blood gas analyses, and other biochemical tests in order to better observe the changes in the condition of the patient during the operation and to ensure patient safety. There have been many reports in the literature about arterial puncture and tube placement and skin infection at the puncture site of arterial tube placement for the past few years. There are fewer reports on the prevention of pressure injury and tube removal after arterial puncture catheterization. With the progress of research and updated knowledge of pressure ulcer guidelines, prevention of pressure injury is crucial (Karacabay et al., 2023). Preventive measures such as enhancing skin care, increasing patient comfort, and reducing the incidence of adverse nursing events can be widely promoted in clinical practice. This study addresses the above issues by skillfully using 3M adhesive tape to facilitate nursing care, increase patient comfort, prevent the occurrence of mechanical pressure injuries, and reduce the incidence of clinical decannulation.

2 MATERIALS AND METHODS

2.1 General information about patients

Purposive sampling method was used to select a total of 120 cases of arterial puncture tube placement and retention patients for inclusion from February 2019 to February 2021 as the study object, which was divided into treatment group, control group 1 and control group 2 using the randomized numerical table method, with 40 cases in each group. Control group 1 was given conventional treatment, and the pressure transducer connector was in direct contact with the patient's skin. In control group 2, a small square of medical gauze was placed under the pressure transducer connector. In the treatment group, 2 × 2cm 3M adhesive tape was placed under the pressure transducer connector. All three groups of patients were fixed with sterile transparent dressing for arterial puncture placement. In addition, there was no statistically significant difference between the age and gender of patients in the three groups ($P > 0.05$, Table 1). These patients were involved in the management by the same group of nurses.

Group	Sex(male/female)	Age
Treatment(n=40)	25/15	48.90 ± 8.34
Control 2(n=40)	26/14	47.75 ± 7.74
Control 1(n=40)	24/16	47.15 ± 6.98
$\chi 2$/F	0.213	0.532
P	0.899	0.589

Table 1 Results of general information

2.2 Inclusion and exclusion criteria

Inclusion criteria: (1) patients younger than 65 years old; (2) patients with application of vasoactive drugs; (3) patients with peripheral edema; (4) patients who signed the informed consent.

Exclusion criteria: (1) patients with intravenous pumped heparin; (2) patients with

severe hepatic or renal disease or other causes of abnormal coagulation parameters (such as oral aspirin); (3) patients with severe heart failure and respiratory failure; (4) Patients with severe pneumonia; (5) Pediatric patients.

2.3 Method

Catheterization method: Arterial puncture catheterization was performed by a charge nurse with at least 6 years of experience under bedside ultrasound guidance. The patient's state of consciousness and the skin condition of the limb on the side of the puncture were assessed on the basis of Allen's test before puncture. For patients who meet the requirements for puncture, a sterile barrier is maximized for puncture placement, and the principles of aseptic operation are strictly adhered to, and the arterial cannula is punctured and retained under ultrasound guidance. The arterial puncture placement tube was properly secured, marked with a red marker, connected to the monitoring unit monitor, and the pressure transducer was secured at the level of the heart. Daily care and assessment of the puncture tube is done according to the recommended requirements of the Guidelines for the Prevention and Treatment of Endovascular Catheter-Related Infections. After successful puncture placement, the catheter was fixed to the skin using 3 different methods, and catheter fixation methods were based on randomized groups.

Fixation method: Control group 1 was given routine treatment and fully exposed the operation area. After routine disinfection and drying, a sterile transparent patch was applied tightly and without tension centered on the puncture point to directly fix the arterial puncture catheterization. After removing the old patch, the skin was disinfected with 2% chlorhexidine acetate in dextrose for 2 times (disinfection area: 10 cm×12 cm) centered on the puncture point. After drying, the patch was replaced by tension-free adhesive method, and the date of replacement was recorded and signed. Record the patient's skin condition around the puncture and blood and fluid exudation according to the International Pressure Sore Guidelines 2016 Edition. In case of skin

damage immediately ask the quality control team for appropriate interventions. Visual analogue scale (VAS) was adopted to record the degree of pain at the puncture site on the nursing intensive care record sheet, and a score of ≤ 3 was regarded as mild pain and judged to be comfortable. In control group 2, a small square of medical gauze was placed under the pressure transducer connector on the basis of control group 1. In the treatment group, 3M adhesive tape (2 × 2 cm) was applied to the underside of the pressure transducer connector on the basis of control group 1.

Quality control assessment: A special team for arterial catheterization was set up, which consisted of nursing supervisor, deputy nursing supervisor, doctors and nurses in ICU. The nursing supervisor was responsible for the quality of nursing care, and the other staff were responsible for developing arterial operating procedures, maintenance and record-keeping programs, and organizing the daily supervision and management of medical and nursing care. The International Pressure Ulcer Guideline (2016 edition) was used as the evaluation tool after consultation by the quality control group. According to the risk level, the medical staff jointly formulated a plan to deal with the problems.

2.4 Observation indicators

Observe the skin damage under the pressure transducer and tube placement joint, catheter displacement, pain and infection incidence in the three groups. According to the criteria of whether the skin of the patient's tube placement site is damaged or not, the damage was counted and the rate of improvement of the skin damage of tube placement was calculated after the application of 3M adhesive tape. At the same time, the VAS was used to assess the pain level of the patients' catheterization sites, and the reliability of the VAS has been confirmed by many researches: the VAS is a straight-line measuring scale from 0 to 10 cm, with 0 indicating no pain and 10 indicating severe pain. The patient marks the pain sensation on the line segment. The distance between the left end of the line segment and the vertical line drawn by the

patient is the patient's subjective pain intensity, with larger numbers indicating more intense pain. A score of ≤ 3 indicates that the patient's pain is effectively relieved, and the relief rate is counted. In the satisfaction evaluation system, patients evaluated their satisfaction with the hospitalization through the "Inpatient Satisfaction Questionnaire". The higher the score, the higher the satisfaction. The questionnaire has been reviewed and adjusted by authoritative experts in ICU, and the structure of each part is reasonable, with good reliability and validity.

2.5 Statistical methods

The count data were described by percentage, and $\chi 2$ test was used for comparison among the three groups. The measurement data were expressed as (mean ± SD), and one-way ANOVA was used for comparison among the three groups (SPSS 27.0). $P < 0.05$ was considered statistically significant.

3 RESULTS

3.1 Results of skin pressure injury

Table 2 and Figure 1 shows the results of skin pressure injury in the 3 groups. There were 9 cases, 12 cases and 24 cases of skin pressure injury in treatment group, control group 2 and control group 1, respectively. The injury rate in the treatment group was 37.5% lower than that in the control group 1 ($P < 0.05$). The injury rate in control group 2 was 30% lower than that in control group 1 ($P < 0.05$). Notably, the injury rate of treatment group was slightly lower than that of control group 2, but there was no significant difference ($P > 0.05$).

Group	Injury	Uninjured	Injury rate
Treatment(n=40)	9	31	9/40 (22.50%) [b]
Control 2(n=40)	12	28	12/40 (30.00%) [c]
Control 1(n=40)	24	16	24/40 (60.00%)

Table 2 Comparison of skin pressure injury among three groups

Note: b represents treatment group compared with control group 1, $P < 0.05$; c indicates $P < 0.05$ for control group 2 compared with control group 1.

In addition, the patients in the treatment group and control group 2 had mainly stage I and II skin pressure injuries (Table 3). Fewer patients in the treatment group had stage II injuries than in control group 2 ($P < 0.05$). Patients in control group 1 had predominantly stage III and IV skin pressure injuries. The number of patients with skin pressure injuries (III-IV) was significantly lower in both treatment and control group 2 than in control group 1 ($P < 0.05$).

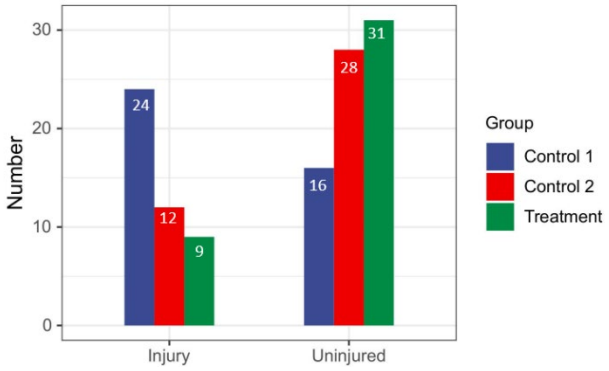

Figure 1 The result of skin pressure injury

Group	I	II	III	IV
Treatment(n=40)	7	2 [a]	0 [b]	0 [b]
Control 2(n=40)	2	8	2 [c]	0 [c]
Control 1(n=40)	3	5	10	6

Table 3 Comparison of the stages of skin pressure injury

Note: a represents the treatment group compared with the control group 2, $P < 0.05$; b represents treatment group compared with control group 1, $P < 0.05$; c indicates $P < 0.05$ for control group 2 compared with control group 1.

3.2 Results of pain score

Table 4 and Figure 2 demonstrate the results of pain score in the 3 groups. There were 29, 21 and 10 patients with pain score less than 3 in treatment group, control group 2 and control group 1, respectively. The pain relief rate of the treatment group was 47.5%

lower than that of the control group 1 ($P < 0.05$). The pain relief rate of control group 2 was 27.5% lower than that of control group 1 ($P < 0.05$). However, the pain relief rate in the treatment group was only slightly higher than that in the control group ($P > 0.05$).

Group	< 3	> 3	Pain relief rate
Treatment(n=40)	29	11	29/40 (72.50%) [b]
Control 2(n=40)	21	19	21/40 (52.50%) [c]
Control 1(n=40)	10	30	10/40 (25.00%)

Table 4 Comparison of pain degree among the three groups

Note: b represents treatment group compared with control group 1, $P < 0.05$; c indicates $P < 0.05$ for control group 2 compared with control group 1.

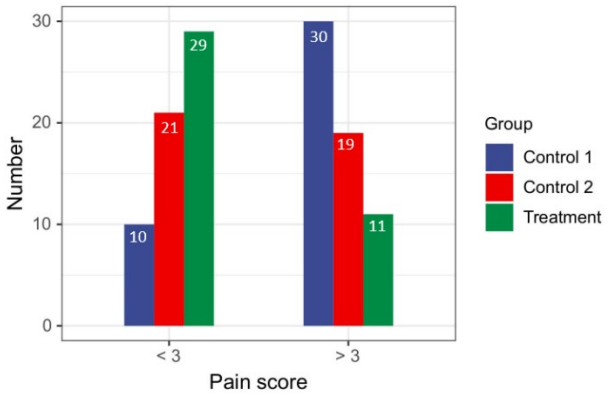

Figure 2 The result of pain score

3.3 Analysis of catheter displacement in patients

Table 5 and Figure 3 present the results of catheter displacement in the 3 groups. Catheter displacement occurred in 3 patients in the treatment group, 10 patients in control group 2, and 13 patients in control group 1. The catheter displacement rate in the treatment group was 17.5% and 25.00% lower than in control 2 and control 1, respectively ($P < 0.05$). However, the rate of catheter displacement in control group 2 was similar to that in control group 1 ($P > 0.05$).

Group	Catheter displacement	No displacement	Catheter displacement incidence
Treatment(n=40)	3	37	33/40 (7.50%) [a, b]
Control 2(n=40)	10	30	21/40 (25.00%)
Control 1(n=40)	13	27	10/40 (32.50%)

Table 5 Comparison of catheter displacement among the three groups
Note: a represents the treatment group compared with the control group 2, $P < 0.05$; b represents treatment group compared with control group 1, $P < 0.05$.

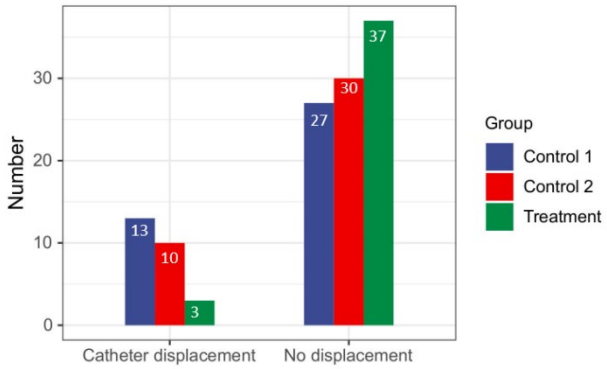

Figure 3 The result of catheter displacement

3.4 Comparison of adverse reactions in patients

Table 6 and Figure 4 depict the results of adverse reactions in the 3 groups. In the treatment group, there was 1 case of infection, 1 case of redness and swelling, and 1 case of bleeding. In control group 2, there were 2 cases of infection, 4 cases of redness and swelling, and 2 cases of bleeding. In control group 1, there were 5 cases of infection, 8 cases of redness and swelling, and 5 cases of bleeding. The total incidence of adverse reactions in the treatment group was 20% and 35% lower than that in the control group 2 and 1, respectively ($P < 0.05$). Obviously, there was no significant difference in the total incidence of adverse reactions between control group 2 and control group 1 ($P > 0.05$).

Group	Infection	Red and swollen	Blood effusion	Total adverse reactions
Treatment(n=40)	1	1	2	4/40 (10.00%) [a, b]
Control 2(n=40)	3	5	4	12/40 (30.00%)
Control 1(n=40)	5	8	5	18/40 (45.00%)

Table 6 Comparison of adverse reactions among the three groups
Note: a represents the treatment group compared with the control group 2, $P < 0.05$; b represents treatment group compared with control group 1, $P < 0.05$.

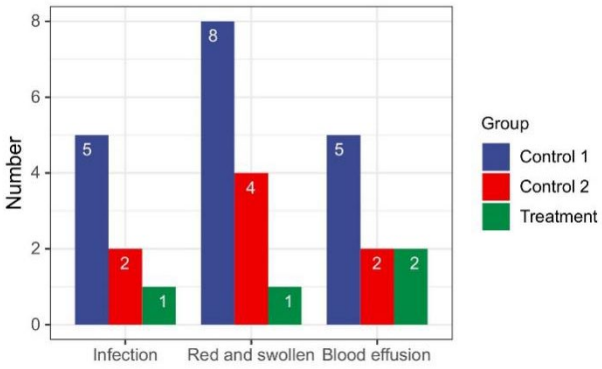

Figure 4 The result of adverse reactions

3.5 Results of patient satisfaction

Table 7 and Figure 5 exhibit the results of patient satisfaction in the 3 groups. In the treatment group, 20 cases were satisfied, 15 cases were generally satisfied, and 5 cases were not satisfied. In control group 2, 10 cases were satisfied, 17 cases were generally satisfied, and 13 cases were not satisfied. In control group 1, 5 cases were satisfied, 12 cases were generally satisfied, and 23 cases were not satisfied. The total satisfaction of the treatment group was 15% and 45% higher than that of the control group 2 and 1, respectively ($P < 0.05$). In addition, the satisfaction of patients in control group 2 was significantly higher than that in control group 1 ($P < 0.05$).

Group	Satisfaction	General satisfaction	Dissatisfaction	Total satisfaction
Treatment(n=40)	20	15	5	35/40 (87.50%) [a, b]
Control 2(n=40)	10	17	13	27/40 (72.50%) [c]
Control 1(n=40)	5	12	23	17/40 (42.50%)

Table 7 Comparison of patient satisfaction among the three groups

Note: a represents the treatment group compared with the control group 2, P < 0.05; b represents treatment group compared with control group 1, P < 0.05. c indicates P < 0.05 for control group 2 compared with control group 1.

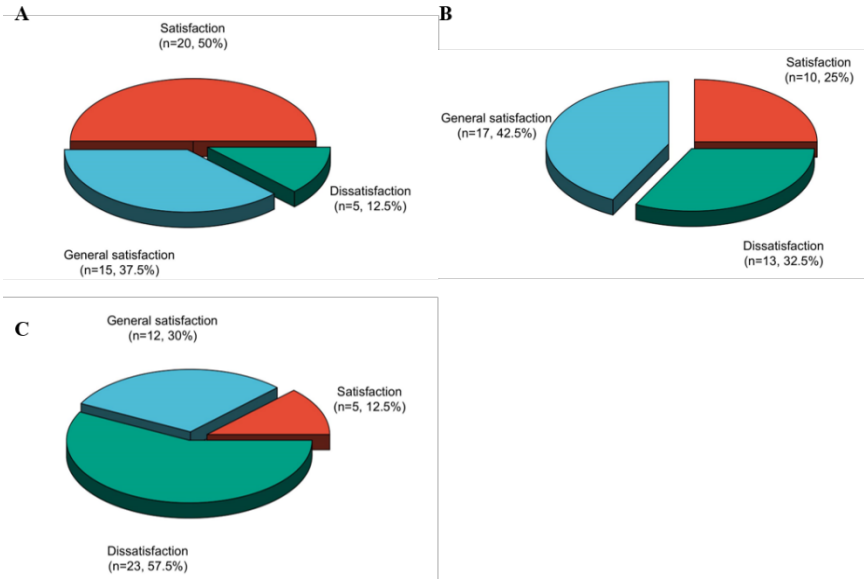

Figure 5 Patient satisfaction in the treatment group, control group 2, and control group 1.

4 DISCUSSION

Arterial puncture catheterization is one of the most commonly used intensive care measures for clinical evaluation, diagnosis and treatment (Yin et al., 2022). Arterial puncture catheterization has important perioperative applications, including hemodynamic monitoring indicators, providing blood samples, and providing pathways for interventional diagnosis and treatment (Kwon et al., 2022; Matheson et al., 2014). However, catheter fixation is prone to cause different degrees of skin damage, which is not conducive to a good prognosis for patients. In this study, we investigated the effect of a modified fixation method in patients after arterial puncture. Our results showed that the incidence of skin pressure injury in the treatment group and control 2 group was lower than that in the control 1 group. At present, most of the catheters in the clinic are fixed directly only with sterile transparent dressings, which tend to put the skin under direct pressure. The characteristics of the catheter, such as hard material, poor elasticity, and inactivity, tend to generate friction and increase tissue pressure, which can easily lead to device-related pressure injuries, in line with the viewpoints pointed out by Jaul (Jaul, 2011). In this study, the use of 3M adhesive tape underneath the joint between the arterial puncture catheter and the pressure

transducer can reduce the vertical pressure of the pressure joint on the skin and decrease the probability of localized stage III-IV pressure injuries (Widiati et al., 2017). The use of medical gauze can also reduce the incidence of injury, but the effect is not as good as 3M tape. Studies have shown that improper immobilization and lack of skin assessment during device use increase the risk of pressure injuries (Aydim Kudu et al., 2023). Therefore, this study confirms that the use of prophylactic dressings for decompression protection and proper immobilization at the point of mechanical contact with the skin can be effective in preventing the occurrence of device-associated pressure injuries.

Medical adhesive-associated skin injuries occur when the integrity of the skin is disrupted due to improper fixation of various dressings and adhesive tapes in the clinic or by increasing the area of contact with the skin, resulting in increased pain for the patient (Card et al., 2023). Pain is now recognized as the fifth vital sign in clinical practice (Gonella et al., 2022). With the severity of pain, it will cause corresponding psychological and physical status, pathophysiological changes, and thus should attract the attention of medical workers (Ballesteros-Peña et al., 2020). The pain score of the treatment group was lower than that of the control group1, which was analyzed because the fixation of a single dressing in the previous clinical practice was improved in this study. The sterile transparent dressing and 3M adhesive tape had better adhesion to the skin, and the contact area was reduced so that the patients did not experience breakage due to cleaning the adhesive skin. It also prevents the catheter from being torn directly from the skin during dressing changes after the intervention and avoids direct contact between the arterial catheter and the skin. Pain level was reduced and comfort was increased, which greatly improved patient satisfaction. At the same time, the results showed that medical gauze also had a pain-relieving effect, but the number of people with a pain score of less than 3 was lower than that of the treatment group.

Arterial puncture catheterization has the advantages of simple, convenient and

practical operation. It is less damaging to the patient's blood vessels and can be left in the artery for a long time. Clinically, the dressing is used to fix the catheter centered on the puncture point, and commonly used dressings include transparent dressings, self-adhesive dressings and hydrocolloid dressings (Li et al., 2023; Liu et al., 2023). If the dressing is not properly applied, catheter displacement is very likely to occur. In this study, the incidence of catheter displacement after the use of 3M adhesive tape was 7.50%, which was lower than that of control group 1 (32.50%) and control group 2 (25.00%). 3M adhesive tape has high elasticity and permeability, and it can be immobilized in a humid environment. After fixation, it is less prone to peeling and loosening, which greatly reduces the likelihood of catheter displacement occurring. The use of 3M adhesive tape also reduced the incidence of adverse events, which may be related to its ability to prevent pressure injuries, catheter dislodgement, and reduce patient pain.

The results of this study showed that patient satisfaction was higher in the treatment group than in control group 1 and control group 2. The majority of ICU patients suffer from systemic dysfunctions, which can lead to abnormal fluctuations in hemodynamic indices. In the course of clinical treatment, it is necessary to closely monitor the patients' vital indicators and collect arterial blood to evaluate some biochemical indicators, which brings a great challenge to the work of nursing staff. However, the use of 3M adhesive tape can effectively reduce the pain of repeated puncture in ICU patients. At the same time, it can also reduce the clinical nursing work, which in turn improves the efficiency of nurses and increases the satisfaction of patients with the nursing work. However, this study still has some shortcomings, the sample source is relatively single and the sample size is small. In future studies, multicenter studies with larger sample sizes should be conducted in order to obtain the best practical evidence for guiding clinical care.

5 CONCLUSION

The application of 3M adhesive tape after arterial puncture catheterization indwelling can effectively prevent the occurrence of skin pressure injury, reduce the occurrence of catheter displacement and adverse reactions, alleviate pain, increase patient satisfaction, and contribute to the clinical nursing work. 3M adhesive tape adheres well to the skin, is easy to separate from the transparent dressing, facilitates the change of medication and prevents detachment of the catheter, and is thinner than medical gauze, which makes the monitoring data more accurate.

DATA AVAILABILITY

The experimental data used to support the findings of this study are available from the corresponding author upon request.

CONFLICTS OF INTEREST

The authors declared that they have no conflicts of interest regarding this work.

FUNDING

The work was not funded by any funding.

REFERENCES

1. Aydim Kudu, A., Tasdemir, N., & Sonmez, M. (2023). Incidence of medical device-related pressure injuries in the intensive care unit and related risk factors. *J Tissue Viability*. https://doi.org/10.1016/j.jtv.2023.06.006

2. Ballesteros-Peña, S., Vallejo-De la Hoz, G., & Fernández-Aedo, I. (2020). Attitudes and Perceptions Surrounding Arterial Puncture for Blood Gas Testing: Differences Between Nurses in the Emergency Department and the Pulmonology Department. *Archivos de Bronconeumología (English Edition)*, *56*(8), 528-530. https://doi.org/10.1016/j.arbr.2020.03.011
3. Card, S., Piersa, A., Kaplon, A., Vanneman, M. W., Dalia, A., Weaver, B., & Hao, D. (2023). Infectious Risk of Arterial Lines: A Narrative Review. *J Cardiothorac Vasc Anesth*, *37*(10), 2050-2056. https://doi.org/10.1053/j.jvca.2023.06.037
4. Ezad, S., & Rawlins, J. (2022). Arterial access for cardiac procedures. *Medicine*, *50*(7), 465-466. https://doi.org/10.1016/j.mpmed.2022.04.013
5. Frota, O. P., Pinho, J. N., Ferreira-Junior, M. A., Sarti, E., Paula, F. M., & Ferreira, D. N. (2023). Incidence and risk factors for medical adhesive-related skin injury in catheters of critically ill patients: A prospective cohort study. *Aust Crit Care*. https://doi.org/10.1016/j.aucc.2023.02.005
6. Gonella, S., Clari, M., Conti, A., Simionato, L., Tassone, C., Berchialla, P., & Campagna, S. (2022). Interventions to reduce arterial puncture-related pain: A systematic review and meta-analysis. *Int J Nurs Stud*, *126*, 104131. https://doi.org/10.1016/j.ijnurstu.2021.104131
7. Imbriaco, G., Monesi, A., & Spencer, T. R. (2022). Preventing radial arterial catheter failure in critical care - Factoring updated clinical strategies and techniques. *Anaesth Crit Care Pain Med*, *41*(4), 101096. https://doi.org/10.1016/j.accpm.2022.101096
8. Jaul, E. (2011). A prospective pilot study of atypical pressure ulcer presentation in a skilled geriatric nursing unit. *Ostomy Wound Manage*, *57(2)*, 49-54.
9. Jia, L., Bi, D., Zheng, H., Chen, C., Lin, Y., Yang, C., Zhang, W., & Wang, Y. (2021). Analgesic Pump Tubing Securement to Prevent Dislodgement of Peripheral Vein Indwelling Catheter. *J Perianesth Nurs*, *36*(5), 480-486 e481. https://doi.org/10.1016/j.jopan.2020.08.003
10. Karacabay, K., Savci, A., Dalkilic, M., & Kabu Hergul, F. (2023). Determining the incidence and risk factors of medical device-related pressure injury in intensive care patients. *J Tissue Viability*. https://doi.org/10.1016/j.jtv.2023.08.002
11. Kwon, Y., Stafford, P. L., Enfield, K., Mazimba, S., & Baruch, M. C. (2022). Continuous Noninvasive Blood Pressure Monitoring of Beat-By-Beat Blood Pressure and Heart Rate Using Caretaker Compared With Invasive Arterial Catheter in the Intensive Care Unit. *J Cardiothorac Vasc Anesth*, *36*(7), 2012-2021. https://doi.org/10.1053/j.jvca.2021.09.042
12. Li, W., Su, Z., Hu, Y., Meng, L., Zhu, F., Xie, B., Wan, J., & Wu, Q. (2023). Mussel-inspired methacrylated gelatin-dopamine/quaternized chitosan/glycerin sponges with self-adhesion, antibacterial activity, and hemostatic ability for wound dressings. *Int J Biol Macromol*, *241*, 124102. https://doi.org/10.1016/j.ijbiomac.2023.124102
13. Liu, F., Wang, L., Zhai, X., Ji, S., Ye, J., Zhu, Z., Teng, C., Dong, W., & Wei, W. (2023). A multi-functional double cross-linked chitosan hydrogel with tunable mechanical and antibacterial properties for skin wound dressing. *Carbohydrate Polymers*, *322*. https://doi.org/10.1016/j.carbpol.2023.121344
14. Matheson, L., Stephenson, M., & Huber, B. (2014). Reducing pain associated with arterial punctures for blood gas analysis. *Pain Manag Nurs*, *15*(3), 619-624. https://doi.org/10.1016/j.pmn.2013.06.001

15. Palmer, J., Gelmann, D., Engelbrecht-Wiggans, E., Hollis, G., Hart, E., Ali, A., Haase, D. J., & Tran, Q. (2022). Invasive arterial blood pressure monitoring may aid in the medical management of hypertensive patients with acute aortic disease. *Am J Emerg Med*, *59*, 85-93. https://doi.org/10.1016/j.ajem.2022.06.054
16. Wang, A., Hendin, A., Millington, S. J., Koenig, S., Eisen, L. A., & Shiloh, A. L. (2020). Better With Ultrasound: Arterial Line Placement. *Chest*, *157*(3), 574-579. https://doi.org/10.1016/j.chest.2019.08.2209
17. Wang, Q., Cai, J., Lu, Z., Zhao, Q., Yang, Y., Sun, L., He, Q., & Xu, S. (2020). Static Ultrasound Guidance VS. Anatomical Landmarks for Subclavian Vein Puncture in the Intensive Care Unit: A Pilot Randomized Controlled Study. *J Emerg Med*, *59*(6), 918-926. https://doi.org/10.1016/j.jemermed.2020.07.039
18. Widiati, E., Nurhaeni, N., & Gayatri, D. (2017). Medical-Device Related Pressure Injuries to Children in the Intensive Care Unit. *Compr Child Adolesc Nurs*, *40*(sup1), 69-77. https://doi.org/10.1080/24694193.2017.1386973
19. Yin, X., Ren, J., Lan, W., Chen, Y., Ouyang, M., Su, H., Zhang, L., Zhu, J., & Zhang, C. (2022). Microfluidics-assisted optimization of highly adhesive haemostatic hydrogel coating for arterial puncture. *Bioact Mater*, *12*, 133-142. https://doi.org/10.1016/j.bioactmat.2021.10.009
20. Zwisler, S. T., Zincuk, Y., Bering, C. B., Zincuk, A., Nybo, M., & Mikkelsen, S. (2019). Diagnostic value of prehospital arterial blood gas measurements - a randomised controlled trial. *Scand J Trauma Resusc Emerg Med*, *27*(1), 32. https://doi.org/10.1186/s13049-019-0612-8

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