Hindawi
Scientific Programming
Volume 2022, Article ID 5276983, 8 pages
https://doi.org/10.1155/2022/5276983

Research Article

Electrocardiograph Positioning on Intubation of Peripherally Inserted Central Catheter and Nursing for Patients with Multiple Myeloma under Deep Learning

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Received 22 October 2021; Revised 21 January 2022; Accepted 28 February 2022; Published 30 March 2022

Academic Editor: M Pallikonda Rajasekaran

This study was to explore the deep learning-based electrocardiograph (ECG) positioning for peripherally inserted central catheter (PICC) patients with multiple myeloma (MM) and provide theoretical guidance for clinical application. In this study, 70 patients with MM were selected as the research object and randomly divided into two groups, 35 cases in each group. The experimental duration was followed for one year. The efficiency of catheterization under the recurrent neural network (RNN) algorithm and the traditional method was evaluated through the operation time. The effects of catheterization were determined by the infection rates after catheterization. *Results*. The time required for PICC catheterization under the guidance of RNN algorithm was 25.6 ± 4.8 min. The time required for PICC catheter surgery under the traditional method was 66.2 ± 5.3 min, which was significantly different from the time required for surgery under the guidance of RNN algorithm ($P < 0.05$). After one year of tracking, under the guidance of RNN algorithm, the cumulative number of infected patients in every two months after PICC catheterization in 35 patients was 0, 0, 0, 0, 1, and 1, respectively. The number of infected patients in the other 35 patients under the traditional method was 0, 0, 0, 1, 2, and 2, respectively. In summary, PICC catheter surgery guided by artificial intelligence algorithm based on RNN neural network required less time and had lower risk of postoperative infection. According to the previous experience, we have summarized the nursing methods after catheterization. In this experiment, compared with the patients who did not follow the doctor's advice, the 70 patients who followed the doctor's advice obtained better therapeutic effects. Postoperative care can ensure the therapeutic effects.

1. Introduction

Multiple myeloma (MM) is a malignant plasma cell disease. The tumor cells are derived from plasma cells in the bone marrow. Clinically, the onset is slow, there are no obvious symptoms in the early stage [1], and it is easy to be misdiagnosed. Clinical examinations mainly include routine biochemical examinations, routine blood examinations, and bone marrow examinations [2]. The treatment mainly includes general treatment and chemotherapy [3]. In clinical practice, intravenous chemotherapy is generally used to treat malignant tumors. Stimulation of chemotherapeutic drugs can easily harden the veins of the patient, cause pain to the patient, increase the workload of the doctor, and are not conducive to the treatment of the disease. In order to ensure proper treatment of patients and protect the health of patients as much as possible [4], peripherally inserted central catheter (PICC) has been taken as a commonly used method of drug infusion in clinical practice. Catheterization can protect peripheral veins, prevent chemical phlebitis and drug leakage damage, establish medium and long-term safe venous access, reduce the pain of patients with repeated venipuncture, and decrease the occurrence of concurrent inflammation after catheterization [5]. Before catheterization, the patient should be carefully explained about the necessity of catheterization and eliminate the patient's fear as much as possible; after catheterization, physical and psychological nursing should be taken [6]. Because the traditional electrocardiograph (ECG) positioning for PICC is post-surveillance [7], the patient has to go to the radiology department for X-ray positioning of the catheter tip after the catheterization by nurse [8]. If the catheter is found to be ectopic, the patient has to be disinfected again to prepare to adjust the ectopic catheter [9], which not only increases the patient's pain but also increases the risk of complications such as infection, phlebitis, and thrombosis caused by catheterization.

Compared with postoperative X-ray film positioning [10], selecting appropriate algorithms for real-time assistance and timely determination of catheter position will greatly improve efficiency, reduce catheterization ectopic rate, protect patient health [11], and reduce resource consumption with the development of artificial intelligence (AI) algorithms in recent years. Deep learning refers to the machine learning based on artificial neural networks (ANN). Different from traditional machine learning [12], deep learning requires more samples, in exchange for less manual labeling and higher accuracy. Deep learning uses depth to replace breadth, further reduces parameters, and improves fitting ability. In many cases, it performs better than traditional machine learning [13]. The traditional back-propagation neural network (BPNN) generally refers to a three-layer fully connected neural network, and the neural network with more than three layers becomes a deep neural network (DNN) that can solve some problems [14], but it is gradually replaced by other network models due to too many parameters. The most used in recent years are convolutional neural networks (CNN) and recurrent neural networks (RNN).

In this study, the RNN algorithm was adopted to analyze the specific application of ECG positioning for PICC of MM patients in clinical practice and the optimization of nursing after catheterization, aiming to provide theoretical guidance for clinical catheterization and nursing after catheterization of MM patients.

2. Materials and Methods

2.1. Research Objects and Their Grouping. The sources of clinical research subjects were 70 patients with MM who were treated with PICC in the hospital from January 2020 to January 2021. Among them, 35 patients received the traditional catheterization, while the remaining 35 patients received the RNN algorithm catheterization. The patients included in the study had undergone pathological examination before surgery. The study has been approved by Ethics Committee of hospital. The patients and their families had a detailed understanding of the research content and method and agreed to sign the relevant informed consent form.

Inclusion criteria: patients who were clinically diagnosed as MM by pathological examination, patients had not been treated with other drugs in the recent study period, and patients had not received radiotherapy and chemotherapy.

Exclusion criteria: patients with mental illness or unconsciousness, patients who were pregnant, patients with incomplete clinical history data, and patients who did not cooperate with treatment.

2.2. Required Materials. The reagents used included hand sanitizer, skin disinfectant, 2% lidocaine, sterile saline, and heparin sodium. The medical materials used included tourniquets, sterile gloves, syringes; PICC puncture kits, catheters, and microintubation sheath kits.

2.3. ECG Positioning for PICC under the Traditional Method. PICC technology had been studied in the 1960s in some foreign countries, and in 1992, the German doctor Forssman successfully completed the first derivative operation with X-ray assisted positioning. It was introduced to China in 1997. The incidence of infection is lower than that of subclavian vein catheterization, there are no life-threatening complications, and the operation is simple. Therefore, in the past ten years, it has been widely used in cancer chemotherapy, stimulating drug infusion, intravenous nutrition therapy, and long-term intravenous infusion in China. The catheter is punctured through a peripheral vein (the expensive vein, the median cubital vein, and the cephalic vein). The positions of the veins are shown in Figure 1. The catheter tip was located at the end of the superior vena cava, close to the superior vena cava and the deep vein at the entrance of the right atrium, so as to provide patients with medium to long-term intravenous treatment.

Traditional catheterization is blind insertion, using the cubital vein as the puncture point. In the preoperative preparation, general clinical information of the patient needs to be collected, including age, past medical history, skin, vein conditions, educational background, and psychological status, and it needs to consult the doctor's advice to develop a puncture plan. After the preparation was complete, the catheter insertion length and arm circumference were measured so that the patient's arm and the body form a 90-degree angle. The puncture should be started from the puncture point to the right sternoclavicular joint and then down to the third intercostal space, as shown in Figure 2. It should be noted that in vitro measurements can never be exactly the same as the vein anatomy in the body. After the length was measured and determined, the skin was disinfected (preferably the entire arm). After, a sterile area was prepared, and it was ready to insert the microcannula sheath kit, as shown in Figure 3. Then, the catheter was preflushed with a syringe sucking with saline, and it had to pay attention to the integrity of the catheter. Next, it had to preflush the extension tube, connector, decompression sleeve, and positive pressure connector to moisten the outside of the catheter so that it invaded the saline, remove the needle cover, and perform puncture at 15–30 °C.

The guide wire was fed along the puncture needle into the blood vessel and kept at least 10–15 cm outside the body; then, the puncture needle was withdrawn to expand the puncture point. The guide wire was fed into the dilator; the dilator was pushed into the vein along the guide wire, and the guide wire and the inner core of the dilator were withdrawn. After the PICC catheter was fed from the cannula sheath to the measured length, the puncture sheath was torn, and the support guide wire was removed. The length of the catheter was trimmed, the connector was

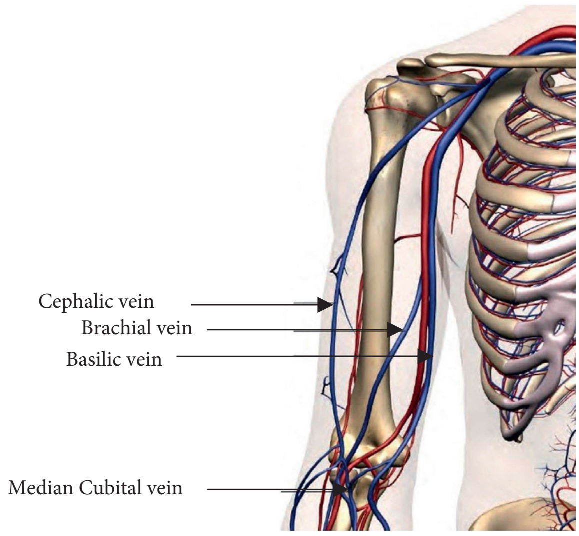

Figure 1: The positions of the veins.

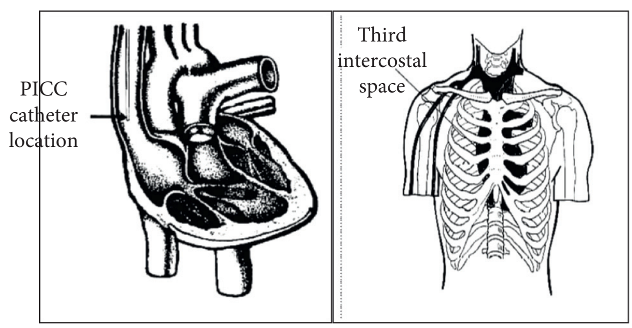

Figure 2: Catheter position.

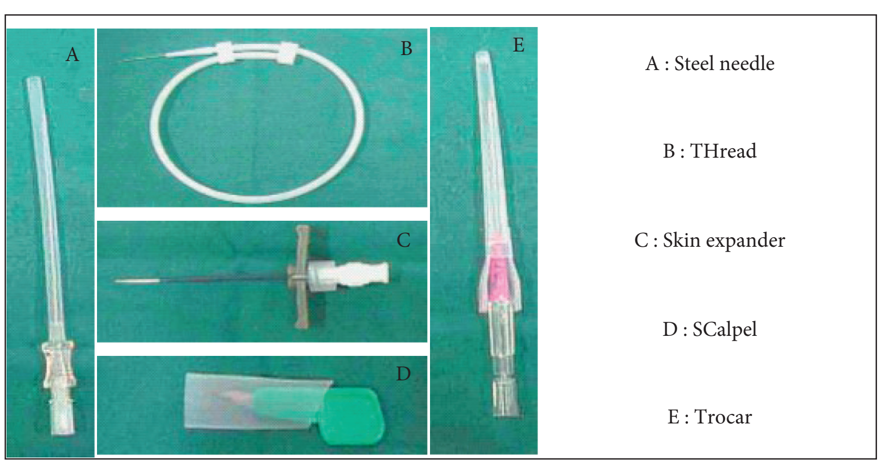

Figure 3: The microcannula sheath kit.

installed, and then the catheter was fixed after the blood was drawn and the tube was flushed.

2.4. ECG Positioning for PICC under Deep Learning. The vein catheterization center of hospital successfully introduced the PICC technology under the RNN. There is no case of catheter-related complications under this technology. With real-time navigation, there was no need to "blind typing" to find the best position for the catheter. RNN is a special neural network structure. It is proposed based on the view that "human cognition is based on past experience and memory." Unlike DNN and CNN, it not only considers the input at the previous moment but also gives the network a sense memory function for the previous content. RNN is called recurrent neural network, that is, the current output of a sequence is also related to the previous output. The main application areas are video processing, language model, image processing, etc. Figure 4 was a simple RNN diagram. It showed that the RNN hierarchy was simpler than CNN. It mainly consisted of an input layer, a hidden layer, and an output layer. In addition, there was an arrow in the hidden layer to indicate the cyclic update of the data, which was the way to realize the time memory function.

Each neuron in RNN had the same function, and its output was called state, denoted by x_j. The collection of all neuron states constituted the state of the feedback network.

$$X = [x1, x2, \ldots, xn]T. \quad (1)$$

The input of the feedback network was the initial value of the state of the network, expressed as below equation:

$$X(0) = [x1(0), x2(0), \ldots xn(0)]T. \quad (2)$$

The feedback network entered a dynamic evolution process from the initial state under external stimulus, and the changing law was given as follows:

$$X_j = f\left(\text{net}_j\right), \quad j = 1, 2, \ldots, n. \quad (3)$$

Transfer functions often take the form of symbolic function/

$$X_j = \text{sgn}\left(\text{net}_j\right) = \left\{\begin{array}{cc} 1 & \text{net}_j < 0 \\ -1 & \text{net}_j < 0 \end{array}\right\}, \quad j = 1, 2 \ldots, n. \quad (4)$$

Net input in the above equation was expressed as follows.

$$\begin{aligned} \text{net}_j &= \sum_{i=1}^{n}\left(w_{ij}x_i - T_j\right), \quad j = 1, 2 \ldots, n, \\ w_{ii} &= 0\, w_{ij} = w_{ji}. \end{aligned} \quad (5)$$

When the feedback network was stable, the state of each neuron was not changing. At this time, the stable state was the output of the network, which could be written as below equation.

$$\text{Lim}X(t), \quad t \longrightarrow \infty. \quad (6)$$

For the asynchronous working mode of RNN neural network, the network had only one neuron to adjust the state at a time, and the state of other neurons remained unchanged, namely,

$$x_j(t+1) = \left\{\begin{array}{cc} \text{sgn}\left[\text{net}_j(t)\right] & j = i \\ x_j(t) & j \neq i \end{array}\right\}. \quad (7)$$

The asynchronous working mode of the RNN neural network was a parallel mode, all neurons adjusted the state at the same time, that was expressed as follows.

$$x_j(t+1) = \text{sgn}\left[\text{net}_j(t)\right], \quad j = 1, 2, \ldots, n. \quad (8)$$

2.5. Nursing after PICC. After PICC, nursing to restrict physical activity is required. The patient was assisted with massage and exercise for 30 minutes a day, which can prevent limb muscle atrophy and joint stiffness, increase upper limb activity appropriately to increase local blood circulation, and prevent excessive activity to prevent the catheter from causing mechanical stimulation to vascular endovascular due to increased limb movement, causing mechanical damage of the catheter to the blood vessel. Nursing for phlebitis was described as follows. It had to observe whether the patient suffered from redness, swelling, and heat pain around and above the puncture point and report to the doctor in time when there were symptoms of phlebitis. Nursing of thrombus after catheterization should be taken as follows. Some predictive measures had to be taken to avoid thrombosis after catheterization, and the patient was explained that a warm towel would be applied to the side vessel of the catheterization once in the morning and evening. It had to pay more attention to the catheterization of patients with MM, observe the situation around the puncture point every day, and measure the circumference of the upper arm to remind patients with catheterization to avoid oppressing the side limbs of the catheterization. The limb with catheterization should be nursed to avoid strenuous exercise to enhance warmth and should be raised to promote blood circulation. The patient had to be guided and educated by nurses before catheterization to let patients realize the superiority of PICC tube and performed psychological nursing to eliminate the patient's nervousness and fear and establish treatment confidence; when the patient was not used to catheterization, the method of carrying PICC catheter had to be explained in daily work so that an independent life can be restored as soon as possible. In response to the lack of knowledge and understanding of PICC maintenance of 70 MM patients after discharge from the hospital with a tube, the detailed personal self-maintenance measures had been formulated; the swelling, heat, and pain at the puncture point should be observed carefully; the patient had to go to hospital in time for abnormalities; the dressing should be changed once a week under the condition of no blood or liquid leakage; the patients and their families had to be instructed to shower and avoid swimming baths and bathing. After catheterization, postoperative nursing should be performed according to the method described earlier. If the doctor's advice could not be followed, it would cause a series of related complications such as catheter blockage. The treatment of hemagglutinative blockage is generally done by appropriately increasing the frequency of catheter flushing using normal saline to ensure that the catheter is unblocked. For nonhemocoagulable blockages, in general, medical staff can clear them by infusion of drugs that can undergo chemical reactions. When the catheter was

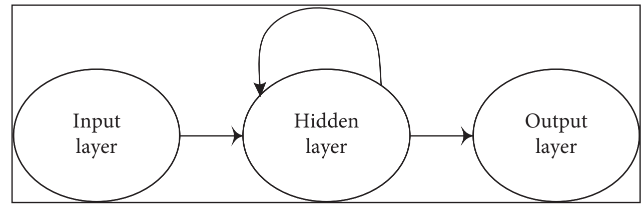

Figure 4: Diagram of RNN.

displaced or prolapsed, the nursing staff should fix the catheter during handling and add auxiliary devices to fix it if necessary. For exudation and blood exudation at the catheterization site and exudation from the puncture site, appropriate human serum protein would be supplemented during treatment for patients with hypoalbuminemia. If there was a catheter defect, it could communicate with the medical staff in time so that the medical staff can judge and deal with the rupture of the internal and external catheters. If phlebitis occurred, it had to pay more attention to rest for mechanical ones, avoid strenuous activities when raising the affected limb, and perform fist exercises appropriately. If bacterial phlebitis occurred, conventional mechanical phlebitis can be treated, and anti-inflammatory treatment with antibiotics or glucocorticoids was necessary. If the effect was not good, it can consider extubation. In routine venous thrombosis, bed rest was taken to relieve pain, and the affected limb was elevated above the level of the heart to improve venous return. For patients with thick blood, anticoagulation therapy should also be maintained in addition to seeking medical staff to replace suitable catheters.

2.6. Observation Indicators. The efficiency of catheterization under the guidance of the RNN algorithm and the traditional method was evaluated by measuring the time spent in surgery; the effect of the two catheterization methods was assessed by measuring the infection rate after the treatment.

2.7. Statistical Analysis. The data processing of this experiment was analyzed by using SPSS 19.0 version of statistical software. The measurement data were expressed by mean ± standard deviation ($x \pm s$), and the counting of quantitative data were expressed by percentage (%) and concentration. The difference was statistically significant with $P < 0.05$.

3. Results

3.1. Chest X-Ray to Determine the Position of the Catheter Tip. Figure 5 shows an X-ray picture of a MM patient. The chest X-rays after catheterization was performed under the traditional method to determine the position of the catheter tip. Figure 5 shows that the catheter tip was in the correct position.

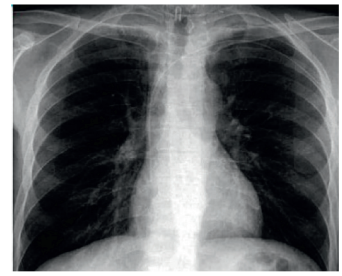

Figure 5: Chest X-ray to determine the position of the catheter tip.

3.2. Various Data Analysis of RNN Algorithm and Nonalgorithm. Figure 6 shows the time required for catheterization. The chart shows that, for five patients selected under the guidance of RNN algorithm, the time required for PICC catheterization was 25 min, 27 min, 28 min, 23 min, and 25 min, respectively. Five patients out of 35 cases who received conventional catheterization were selected. The operation time of PICC catheterization was 55 min, 57 min, 107 min, 59 min, and 53 min, respectively.

In Figure 7, the average operation time under the guidance of RNN algorithm was compared with that of the traditional method. The average operation time under the guidance of RNN algorithm was 25.6 ± 4.8 min and that of the traditional method was 66.2 ± 5.3 min, showing a significant difference compared with the required operation time under the guidance of the algorithm ($P < 0.05$).

Figure 8 shows the number of infected patients after catheterization. Under the guidance of RNN algorithm, the cumulative number of infected patients in every two months after PICC catheterization in 35 patients was 0, 0, 0, 0, 1, and 1, respectively. Under the traditional method, the cumulative number of infected patients in the remaining 35 patients after PICC catheterization every two months was 0, 0, 0, 1, 2, and 2, respectively.

4. Discussion

The PICC technique guided by the RNN algorithm is currently one of the latest and most advanced techniques [15]. Its main difference from the traditional method is that it is coordinated with color ultrasound and intracavitary electrocardiography during the catheterization process to accurately position, avoiding large blood vessels and nerves and looking for the best vascular puncture site and catheter exit [16]. It means to find an optimal position for the catheter through the real-time navigation system in the body. The traditional PICC method is supervised afterwards; that is, after the nurse's catheterization, the patient goes to the radiology department or takes X-rays at the bedside for catheter tip positioning [17]. If the catheter is found to be ectopic, the patient has to perform disinfection and other preoperative preparations to adjust the ectopic catheter, which not only increases the patient's pain but also increases the risk of complications such as infection, phlebitis, and thrombosis caused by catheterization. Compared with postoperative X-ray film positioning, positioning under the RNN algorithm can provide real-time guidance during the catheterization process and determine the catheter position in time, thereby effectively reducing the ectopic rate of catheterization [18], making the one-time positioning accuracy rate more than 95% [19]. In this case, it relieves patient discomfort and economic costs caused by adjusting the catheter ectopic position and reduces the workload of catheterization. Foreign multicenter clinical randomized controlled studies have shown that it can significantly reduce the incidence of catheterization-related complications such as devascularization and thrombosis and can reduce the probability of infection by 10 times. In addition, the safety is improved, and the economy is also considerable [20]. Due to

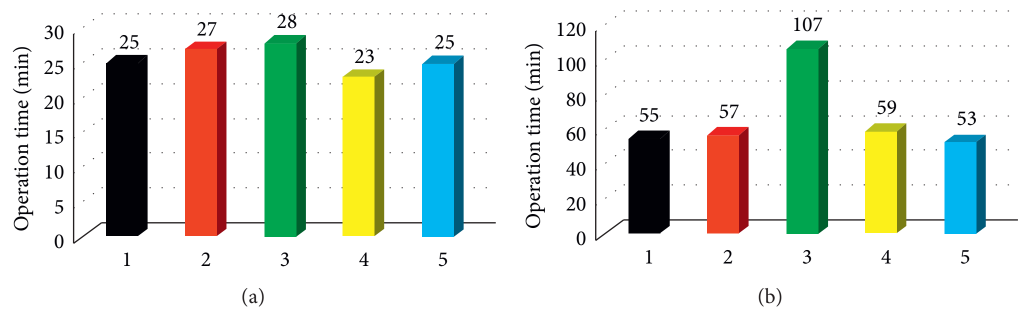

Figure 6: The time required for catheterization surgery. (a) The times required for PICC for five patients under the guidance of the RNN algorithm; (b) the times required for PICC for five patients under the guidance of the traditional method.

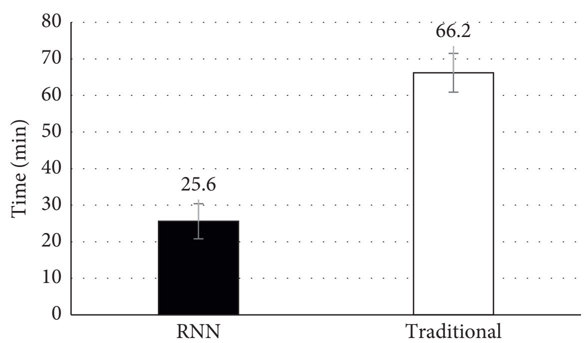

Figure 7: The operation time of two methods. ∗ suggested that the difference was statistically observable in contrast to the time under the traditional method ((P) < 0.05).

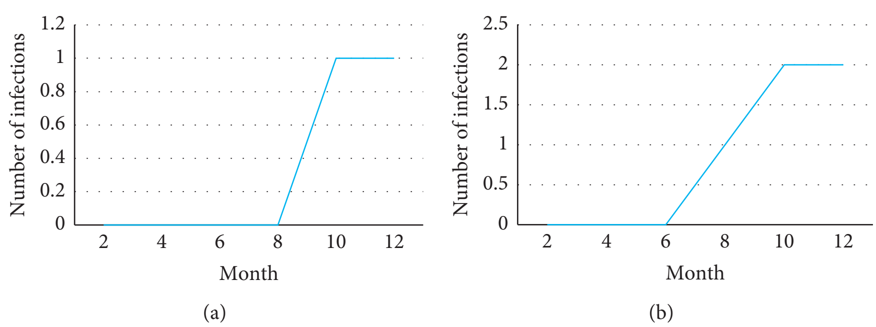

Figure 8: Number of infected patients after catheterization surgery. (a) The results under RNN algorithm; (b) the results under the traditional method.

the increase in residence time, the occurrence of catheter misalignment is reduced, and the extra filming costs of patients adjusting catheter position are reduced, the labor cost of catheterization nurses is reduced, and the comfort of patients is improved. As a long-term indwelling, high-efficiency, safe, and economical catheterization method, PICC provides a lot of help for cancer patients. It not only reduces the pain of cancer patients to a certain extent but also provides a guarantee for life safety for patients.

In this study, 70 patients with MM were divided into two groups, and the duration of the tracking experiment was one year. The results showed that the time required for PICC catheterization under the guidance of RNN algorithm was 25.6 ± 4.8 min. The time required for PICC catheter surgery under the traditional method was 66.2 ± 5.3 min, which was significantly different from the time required for surgery under the guidance of RNN algorithm ($P < 0.05$). After one year of follow-up experiment, the data showed that, under the guidance of RNN algorithm, the cumulative number of infected patients in every two months after PICC catheterization in 35 patients was 0, 0, 0, 0, 1 and 1, respectively. According to the survey, the main cause of infection in patients was to take a bath without listening to doctor's advice. Under the traditional method, the cumulative number of infected patients in the remaining 35 patients who underwent PICC catheterization at two month intervals was 0, 0, 0, 1, 2 and 2, respectively. The patients followed the doctor's advice, and the reason was speculated to be related to the nonstandard aseptic operation technology during the catheterization with the traditional method. For example, the partial disinfection during puncture was not strict, the protection after the joint used was contaminated improperly, and the disinfection during the connection with the infusion set was not strict, all of which could bring bacteria into the official cavity to cause infection. According to the nursing methods after catheter placement summarized from previous experience, compared with those who did not follow the doctor's advice, the experimental group in accordance with the doctor's advice obtained better therapeutic effects and saved medical resources.

5. Conclusion

In this study, the RNN neural network artificial intelligence algorithm model was constructed for real-time detection in the PICC catheter, so as to study the positioning of patients with MM PICC catheter based on deep learning ECG and its nursing. The results showed that, under the guidance of artificial intelligence algorithm based on RNN neural network, the operation time of PICC catheterization was required to be less, and the risk of postoperative infection was lower. For patients, the differences between the data results were not significant, the stability of the system was high, and it had good clinical effect on the adjuvant treatment of MM patients. However, the sample size of cases selected in this study is small, which may affect the experimental results to a certain extent. At the same time, it lacks comparison with other intelligent algorithms and other diseases, and its representation is low. Therefore, sample size selection will be increased in subsequent experimental studies, and other algorithms will be adopted as well as the effect of artificial intelligence algorithm on ECG positioning of PICC catheter for further studies on other diseases. In conclusion, this study provided a theoretical basis for studying the patients with MM PICC catheter positioning based on deep learning ECG in clinical practice and their nursing care.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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