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Research Article

Explore the Applications of Nano-Silver Polyurethane Skin Wound Dressing

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ABSTRACT

Polyurethane is a medical material, which has excellent physical properties and high mechanical compatibility. At present, one of the most effective application methods for antibacterial bacterial biofilm is to combine polyurethane with nano-silver, so that the polyurethane material itself has bactericidal performance and finally plays a good antibacterial effect. From August 2011 to January 2014, 75 patients with crush injury or avulsion injury who had difficulty healing were randomly divided into 5 groups.

Results: Comparison of colony count results of different concentrations of nano-silver polyurethane; comparison of colony count results of two groups in vitro; comparison of anticoagulant degree and determination of whole blood coagulation time; comparison of coagulation routine examination results of two groups; comparison of epithelial growth factor levels at different time after treatment; comparison of tumor necrosis factor- α levels at different time after treatment between two groups; comparison of change times, visual analogue score of pain during treatment and hospitalization time of two groups; comparison of white blood cell count of two groups of polyurethane patients within 1 week; comparison of clinical efficacy between two groups.

Conclusion: The medical material containing nano-silver polyurethane is a good bacteriostatic biomaterial, which can inhibit common iatrogenic pathogens in vitro. The application of 5% nano-silver polyurethane medical material to open wound, especially in patients with avulsion and crush injury in orthopaedics, can inhibit the growth of common hospital pathogenic bacteria. can significantly reduce the level of tumor necrosis factor- α in the wound, reduce the local inflammatory response, and can significantly improve the clinical effect of the treatment of complex wounds, which is worthy of clinical promotion.

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Objective

Polyurethane is a medical material having excellent biocompatibility, which has excellent physical properties and improved mechanical compatibility of materials, the polyurethane has been widely used in the current medical procedure, but it appears after implantation of human infection cannot be ignored, once infected, mostly for its multi-drug resistant pathogens, currently the most widely used against bacterial biofilms method is polyurethane material with a combination of nano-silver, which has bactericidal properties of the implant material in the polyurethane material itself, play a good antibacterial effect. In this study, *in vitro* experiments comparing different concentrations of nano-silver antibacterial effect of polyurethane on *Staphylococcus aureus*,

Escherichia coli and *Candida albicans*, and then choose the best pure polyurethane nano-silver antibacterial effect comparing medical polyurethane material explore the nano-silver polyurethane applications in the orthopedic wounds.

Methods

120 cases of refractory wound in our hospital from August 2011 to January 2014 were treated, according to the figures were randomly divided into two groups, each of 60 cases, all patients met the inclusion and exclusion criteria. Between pure polyurethane material group and nano-silver polyurethane group, differences in patient sex, age, area of the wound, causes of injury, the wound site, and prior treatment such as no statistically significant ($P > 0.05$), comparable, while 0.5% 1%, 2%,

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and between silver polyurethane, differences in patient sex, age, area of the wound, causes of injury, the wound site, and no previous treatment such as nano four concentrations of 5% statistical significance ($P > 0.05$), comparable.

All patients signed an informed before enrollment system consent and approval of the hospital ethics committee reported, this study is divided into two main steps, first prepared with different concentrations of nano-silver polyurethanes and polyurethane material choice purely medical *in vitro* tests, by *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans* culture counting judgment and choose a better antibacterial polyurethane material, polyurethane material after selecting the best antimicrobial activity, medical polyurethane material with a simple comparison, two dressing frequency, pain during treatment score and length of hospital stay, three days after the statistical treatment of the two groups of polyurethane wound healing, and calculation analysis one day after treatment, three days after treatment, both groups after treatment seven days a polyurethane white blood cell count in patients at the time of the last patient was discharged after treatment or when comparing two treatment need surgery again.

Results

Silver polyurethane colony count results comparing different concentrations of different concentrations of nano- nano-silver polyurethane colony count comparison, with nano silver antimicrobial concentration is elevated capacity enhancement, of which 5% polyurethane nano-silver group cultured colonies of *Staphylococcus aureus* (1.98 ± 0.25) $\times 10^6$ Cfu/ml, less than 2% polyurethane nano-silver group (2.30 ± 0.23) $\times 10^6$ Cfu/ml, less than 1% polyurethane nano-silver group (2.78 ± 0.43) $\times 10^6$ Cfu/ml, below 0.5% nano silver polyurethane group (3.02 ± 0.23) $\times 10^6$ Cfu/ml ($P < 0.05$), 5% of polyurethane nano silver coli colonies was cultured group (4.66 ± 0.30) $\times 10^6$ Cfu/ml, less than 2% nano silver polyurethane group (5.10 ± 0.46) $\times 10^6$ Cfu/ml, less than 1% polyurethane nano-silver group (6.26 ± 0.50) $\times 10^6$ Cfu/ml, less than 0.5% of nano-silver polyurethane group (7.04 ± 0.36) $\times 10^6$ Cfu/ml ($P < 0.05$), 5% polyurethane nano-silver group culture of *Candida albicans* colonies was (1.36 ± 0.27) $\times 10^6$ Cfu/ml, less than 2% lower than the nano silver polyurethane group (1.71 ± 0.27) $\times 10^6$ Cfu/ml, 1% nano silver polyurethane group (2.10 ± 0.30) $\times 10^6$ Cfu/ml, nano-silver is less than 0.5% of polyurethane group (2.54 ± 0.42) $\times 10^6$ Cfu/ml ($P < 0.05$).

In vitro test results comparing the two groups of colonies counted after 1 week *in vitro* tests found that 5% of polyurethane nano-silver group *Staphylococcus aureus* colony count (1.87 ± 0.29) $\times 10^6$ Cfu/ml, significantly less than the pure polyurethane materials group (3.52 ± 0.38) $\times 10^6$ Cfu/ml ($P < 0.05$), 5% polyurethane nano-silver group *Escherichia coli* colony count (4.53 ± 0.44) $\times 10^6$ Cfu/ml, significantly less than the pure polyurethane materials group (7.57 ± 0.41) $\times 10^6$ Cfu/ml ($P < 0.05$), 5% polyurethane nano-silver group *albicans* colony count (1.36 ± 0.22) $\times 10^6$ Cfu/ml, significantly less than the pure polyurethane materials group (2.62 ± 0.32) $\times 10^6$ Cfu/ml ($P < 0.05$).

The extent of each group of anti-coagulation and clotting time was measured comparing the group found (0.552 ± 0.069), the degree of anti-coagulation was significantly lower than 5% polyurethane nano-silver group 2% polyurethane group (0.569 ± 0.087), low 1% polyurethane

nano-silver group (0.553 ± 0.088), less than 0.5% of nano-silver polyurethane group (0.544 ± 0.064) ($P < 0.05$), while 5% polyurethane nano-silver group (8.63 ± 0.60) min, the whole blood clotting time was significantly longer than 2% of nano-silver polyurethane group (7.21 ± 0.54) min, longer than 1% of nano-silver polyurethane group (6.52 ± 0.55) min, longer than the 0.5% nano silver polyurethane group (6.05 ± 0.58) min ($P < 0.05$).

Routine coagulation test results for each group of 5% polyurethane nano-silver group APTT time was (34.64 ± 1.12) s, longer than the 2% polyurethane nano-silver group (30.53 ± 0.61) s, longer than 1% polyurethane nano-silver group (25.56 ± 0.48) s, longer than the 0.5 percent polyurethane nano-silver group (24.43 ± 0.63) s ($P < 0.05$), 5% polyurethane nano-silver group PT time was (13.56 ± 1.04) s, longer than the 2% polyurethane nano-silver group (12.46 ± 0.67) s, longer than 1% polyurethane nano-silver group (11.08 ± 0.51) s, longer than the 0.5 percent polyurethane nano-silver group (10.25 ± 0.66) s ($P < 0.05$), 5% polyurethane nano-silver group TT time (14.33 ± 1.21) s, longer than the 2% polyurethane nano-silver group (13.09 ± 0.54) s, longer than 1% polyurethane nano-silver group (11.69 ± 1.00) s, longer than the 0.5 percent polyurethane nano-silver group (11.36 ± 0.55) s ($P < 0.05$).

Dressing two times during the treatment of pain visual analog scale score, and treatment during the hospital stay of 5% polyurethane nano-silver dressing group, the total number of (1.86 ± 0.12) times, significantly lower than the pure polyurethane materials group (5.16 ± 0.15) times ($P < 0.05$), during treatment in patients with pain visual analog scale score, 5% polyurethane nano-silver group (1.52 ± 0.16) points, significantly lower than the pure polyurethane materials group (4.22 ± 0.17) ($P < 0.05$), postoperative hospital stay, the 5% polyurethane nano-silver group (7.94 ± 0.16) days, significantly less than (12.21 ± 0.19) days of pure polyurethane material group, ($P < 0.05$).

3 days after treatment, both groups of polyurethane wound healing compared to the situation three days after treatment by the same physician tube bed unified evaluation of wound healing, in which 5% of the group wound polyurethane nano-silver ratio reached 46.7% dry scab, significantly higher than the pure polyurethane material group wound dry scab ratio of 26.7% ($P < 0.05$), another group of pure polyurethane material wound reduction ratio of 18.3 % pure polyurethane material group wound swelling ratio, 5% polyurethane nano-silver wound group reduction ratio was 23.3 %, 5% polyurethane nano-silver wound swelling ratio group was 21.7 %, 5% polyurethane nano-silver ratio of the group wound secretions increase of 8.3 %, 5 % polyurethane nano-silver wound swelling and secretions group had increased overall rate of 55.0 %, significantly lower than 30.0% pure polyurethane material group ($\chi^2 = 7.673$, $P = 0.006$).

1 week comparing two groups of white blood cell counts in patients with polyurethane that one day a week after treatment, after treatment, after 3 days and 7 days treatment in patients with WBC count two polyurethane comparison, 5% polyurethane nano-silver group leukocyte count were within the normal range while pure polyurethane material group were higher than normal white blood cell count range, which after 5% polyurethane nano-silver treatment group one day leukocyte count (6.57 ± 0.54) $\times 10^9$ / L, significantly lower than the pure polyurethane materials group (10.64 ± 0.94) $\times 10^9$ / L ($P < 0.05$), 5% polyurethane nano-silver three days after treatment leukocyte count (7.96 ± 0.69) \times

109 / L, significantly lower than the pure polyurethane materials group (17.51 ± 0.86) \times 109 / L ($P < 0.05$), 5% polyurethane nano-silver group seven days after treatment, white blood cell count was (7.16 ± 0.54) \times 109 / L, significantly lower than the pure polyurethane materials group (13.49 ± 0.84) \times 109 / L ($P < 0.05$).

After treatment of epithelial growth factor levels at different times compare 1 week after treatment, i.e. 1 day, 3 days after treatment, both groups seven days after treatment in patients with epidermal growth factor levels polyurethane comparison, one day after treatment, pure polyurethane material group epidermal growth factor (26.90 ± 0.33) pg / ml, significantly lower than the 5% polyurethane nano-silver group (34.26 ± 0.40) pg / ml ($P < 0.05$), 3 days after treatment, pure polyurethane material group epidermal growth factor (39.36 ± 0.36) pg / ml, significantly lower than the 5% polyurethane nano-silver group (45.43 ± 0.75) pg / ml ($P < 0.05$), 7 days after treatment, pure polyurethane material epidermal growth factor group (45.32 ± 0.28) pg / ml, significantly lower than 5% of polyurethane nano silver group (102.45 ± 0.84) pg / ml ($P < 0.05$).

Different time levels of tumor necrosis factor - α comparative treatment groups after 1 week 1 day, 3 days after treatment, after treatment in patients with relatively seven days two polyurethane levels of tumor necrosis factor - α treatment that is, one day after treatment, pure polyurethane materials tumor necrosis factor - α was (11.62 ± 2.19) pg / ml, significantly higher than the 5% polyurethane nano-silver group (5.35 ± 0.71) pg / ml ($P < 0.05$), 3 days after treatment, pure polyurethane material group tumor necrosis factor - α was (23.15 ± 2.20) pg / ml, significantly higher than the 5% polyurethane nano-silver group (4.13 ± 0.90) pg / ml ($P < 0.05$), 7 days after treatment, tumor necrosis pure polyurethane material factor - α was (52.58 ± 2.86) pg / ml, significantly higher than the 5% polyurethane nano-silver group (4.35 ± 0.55) pg / ml ($P < 0.05$).

When comparing the clinical efficacy of the two groups when the patient was discharged after treatment or require reoperation were compared treatment effects, of which 5% polyurethane nano-silver ratio reached 50.0% in the group of excellent and good rate of 21.7%, good rate of 71.7%, significantly higher than excellent pure polyurethane material group rate 45.0% ($\chi^2 = 8.777$, $P = 0.003$).

Conclusion

Polyurethane dressings containing nano silver *in vitro* tests can be better inhibition of *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans* growth, with significant antimicrobial activity, and the higher the concentration, the stronger antimicrobial activity. Containing 5% polyurethane nano- silver wound dressings used in the open, especially in the orthopedic crush, avulsion of patients, as opposed to simply an ordinary medical polyurethane material that is better able to inhibit *Staphylococcus aureus*, *Escherichia coli*, white fake *Candida* growth.

Containing 5% polyurethane dressing silver nanoparticles used in open wounds, especially in the orthopedic RCC, degloving injury patients, can significantly reduce the degree of anticoagulant, and extend the whole blood coagulation time, more conducive to patient airframe anticoagulant, prevent thrombosis. Containing 5% polyurethane dressing silver nanoparticles used in open wounds, especially in the

orthopedic RCC, degloving injury patients, can significantly extend the plasma prothrombin time (APTT), thrombin time (PT) and some activated clotting time (TT) live enzymes, effectively reduce the influence on blood coagulation function in patients with, to reduce and prevent the formation of blood clots.

Containing 5% polyurethane nano- silver wound dressings used in the open, especially in the orthopedic crush, avulsion patients can significantly reduce the number of postoperative wound dressing, pain during patient treatment of patients and shorter hospital stays. Containing 5% polyurethane nano- silver wound dressings used in the open, especially in the orthopedic crush, avulsion patients, can promote wound soon dried and crusted, to reduce wound purpose, while reducing swelling and increased secretions phenomenon. Containing 5% polyurethane nano- silver wound dressings used in the open, especially in the orthopedic crush, avulsion patients, can significantly improve the clinical effect of the treatment of complicated wounds, worthy of promotion.

Containing 5% polyurethane nano-silver wound dressings used in the open, especially in the orthopedic crush, avulsion patients, can significantly increase the wound epidermal growth factor levels and promote wound regeneration and repair. Containing 5% polyurethane nano-silver wound dressings used in the open, especially in the orthopedic crush, avulsion patient, the wound can significantly reduce levels of tumor necrosis factor- α , reduce local inflammation.

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