RESEARCH ARTICLE

Effects of Anson nano silver combined with red light therapy and comprehensive nursing intervention on post-cesarean wound healing and scar formation

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Post-cesarean wound complications and scar formation continue to pose significant challenges. Conventional methods for managing wounds have limitations in enhancing healing and achieving desirable cosmetic results. Nano silver, red light therapy, and comprehensive nursing intervention (CNI) show potential in wound management. However, evidence of their combined effectiveness remains limited. This study explored the effects of Anson nano silver (ANS) combined with a red light therapy apparatus (RLTA) and CNI on incision healing and scar formation after cesarean section (CS). A total of 100 postpartum women who underwent CS in the Department of Obstetrics and Gynecology, Yichang Maternity and Child Health Care Hospital, Yichang, Hubei, China from January 2019 to January 2022 were enrolled in this study. The participants were randomly assigned to a control (Ctrl) group and an experimental (Exp) group. The Exp group immediately applied using ANS alongside routine local wound treatment (RLTA) and received conventional nursing interventions (CNI), while the control group received only CNI including wound cleaning, disinfection, and dressing. Incision healing of the patients was meticulously monitored, and pertinent statistics were collected. No visible difference was observed in general incision comparison between two groups, indicating comparability. After different interventions, incision healing, wound healing time, scar grade, and incision pain level in the Exp group improved markedly compared to that in the Ctrl group ($P < 0.05$). The results indicated that the combination of ANS, RLTA, and CNI had a significant effect on post-cesarean incision healing and scar formation.

Keywords: cesarean section; incision healing; scar formation; Anson nano silver; red light therapy; comprehensive nursing intervention.

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Introduction

A cesarean section (CS) is a surgical procedure involving incisions in the abdomen and uterus to deliver the fetus [1]. CS is typically performed when other methods of delivery are not feasible or safe [2]. Moreover, some women may opt for a CS instead of natural childbirth due to concerns about potential pain or complications [3]. CS rates are rising globally with projections indicating an increase from 21.1% in 2018 to 28.5% by 2030 and to as high as 50% in some regions. Current rates vary substantially across countries with 32.1% in the United States, 30% in Japan, 20% in France, 30% in Poland, and significantly higher rates of 60% in some parts of

Latin America and China, and up to 80% in Brazil's private sector [3-5]. Although CS serves as a critical surgical intervention that has effectively reduced maternal and fetal mortality, the increased rates have raised concerns about surgical site infections, delayed healing, excessive inflammation, and abnormal collagen deposition, which can result in wound dehiscence, hypertrophic scars, and keloid formation [3]. Additionally, post-cesarean wound complications and unsatisfactory scar formation affect about 3 – 15% of cases and remain a prominent clinical challenge, adversely affecting recovery, quality of life, and cosmetic outcomes [4, 6]. These complications also impose physical discomfort, psychological burden, increased healthcare costs, and longer hospital stays [6]. Therefore, promoting optimal healing of CS incisions has remained a focal point in clinical practice [7].

The process of incisional wound healing after CS is complex and involves interactions among various factors including growth factors and cytokines [8]. It is a highly orchestrated, sequential biological process composed of overlapping phases including hemostasis, inflammation, proliferation, and remodeling. The ultimate goal of wound healing is to replace damaged cells and restore skin integrity. For proper wound restoration, these processes must occur in the correct sequence [5], and disruptions in any phase can impair healing and promote excessive scar formation or chronic wounds [9]. The rate of incisional healing and postoperative scar formation is influenced by multiple factors including individual differences, surgical techniques, and wound care [10]. Conventional wound management approaches including standard dressings and antibiotic prophylaxis, though effective in reducing infections, are limited in addressing issues such as delayed healing, excessive inflammation, and pathological scarring that adversely affect recovery [11]. Recent advances in wound care have introduced antimicrobial nanotechnology including silver nanoparticles, and photobiomodulation therapy such as red light therapy to enhance healing outcomes. Anson nano silver (ANS) is a colloidal solution of silver nanoparticles synthesized *via* nanotechnological processes. Its distinct physicochemical characteristics confer a range of functions [12]. Silver nanoparticles possess a large surface-area-to-volume ratio and reactivity, facilitating contact with bacteria and exerting excellent antibacterial effects at low concentrations [13, 14]. Moreover, nano silver exhibits potent anti-inflammatory effects. Because of its small particle size and high dispersibility, nano silver can rapidly penetrate inflamed areas and inhibit inflammatory reactions [15], which makes ANS an ideal choice for treating inflammatory conditions. Nano silver also promotes wound healing by stimulating cell proliferation and differentiation, accelerating the formation of new tissue. Studies have shown that the use of ANS for post-CS incisions can successfully inhibit bacterial infections, reduce inflammation, and accelerate wound healing [16]. ANS rapidly permeates incisional tissue, interacts with bacteria, and disrupts their cell walls, achieving antibacterial effects [17]. Simultaneously, ANS can enhance the proliferation and differentiation of epithelial cells at the wound surface, accelerating the wound-healing process. The red light therapy apparatus (RLTA) is a device that employs infrared light irradiation to promote wound healing [18]. Red light stimulates blood circulation in wound tissue, increasing oxygen and nutrient delivery and accelerating wound repair and regeneration. It can also promote collagen production, an essential structural protein that supports the flexibility and integrity of damaged tissue [19]. By enhancing collagen synthesis, red light can reduce the risk of scar formation, resulting in smoother, more natural wound healing. Therefore, this non-invasive, non-pharmacological, high-tech medical device exerts unique effects on wound healing and scar formation by improving tissue regeneration, reducing inflammation and pain, and promoting angiogenesis and collagen synthesis [20-24]. Comprehensive nursing intervention (CNI) is a comprehensive nursing approach that involves a holistic assessment of patients and the

development of personalized care plans by integrating various nursing interventions and techniques to promote patient recovery and enhance their quality of life [25, 26]. It is essential for optimizing wound healing outcomes after CS and includes rigorous wound care protocols, patient education on self-care and infection prevention, pain management, and psychosocial support. CNI also ensures adherence to best clinical practices, promoting functional wound healing and minimizing poor scar formation [27].

Despite evidence supporting each intervention individually, synergistic potential of combining nano silver, red light therapy, and CNI for post-cesarean wound healing remains to be systematically evaluated to establish multimodal clinical protocols that maximize both healing quality and cosmetic outcomes. This study investigated the effects of the combined use of ANS, CNI, and RLTA on CS incision healing and scar formation, aiming to explore an effective method to promote incision healing and reduce the risk of scarring after the procedure. The effectiveness of the intervention was assessed by comparing clinical outcomes including incision healing time, scar formation evaluated using the Vancouver Scar Scale (VSS), postoperative pain levels, and overall incision healing status between the control and intervention groups. The results of this study provided evidence for a multimodal approach to post-cesarean wound management, addressing a significant gap in current clinical practice, and contributed to the integration of antimicrobial nanotechnology, photobiomodulation, and CNI to optimize surgical wound healing and minimize scar formation, which might guide clinical decision-making and improve both functional and aesthetic outcomes for postpartum women undergoing CS.

Materials and methods

Recruitment and grouping of study subjects

A total of 100 postpartum women who underwent CS in the Department of Obstetrics and Gynecology, Yichang Maternity and Child Health Care Hospital, Yichang, Hubei, China between January 2019 and January 2022 were included in this research. The inclusion criteria were age 18 - 40 years, having CS surgery and completing the postoperative recovery period, good incision healing without signs of infection, absence of significant systemic illnesses, no prior history of ANS or RLTA. The exclusion criteria were undergoing other surgical interventions, presence of severe postoperative complications, other chronic or immune system-related diseases, pregnancy complications, or known allergies to components of ANS, RLTA, or related treatment methods. The participants were randomly divided into the control (Ctrl) and experimental (Exp) groups with 50 participants in each group. Both groups received CNI interventions immediately after CS surgery with the Exp group additionally receiving ANS followed by RLTA treatment. All interventions lasted for 4 weeks after CS surgery. The Exp group participants had a mean age of 28.32 ± 4.23 years old and mean body weight of 64.31 ± 8.32 kg with 8 having miscarriage history, 34 uniparous, and 16 multiparous. The Ctrl group participants had a mean age of 28.41 ± 5.03 years old and mean body weight of 63.97 ± 7.91 kg with 6 having miscarriage history, 35 uniparous, and 15 multiparous. All procedures of this study were approved by the Ethics Committee of Hubei Three Gorges Polytechnic (Yichang, Hubei, China) (Approval No. 2026-EC-063).

Post CS surgery interventions

(1) Application of CNI

The CNI protocol encompassed a series of measures designed to accelerate wound healing and prevent scar formation such as regular dressing changes to keep the incision clean and dry, minimizing inflammation and local pressure, promoting balanced nutrition, increasing nutrient intake, and engaging in moderate exercise. Indicators of redness, exudate, and pain at the incision site were recorded and regularly assessed. Additional relevant data were collected including body temperature and white blood cell count (WBC) to provide a comprehensive

assessment of incisional healing and the overall health status.

(2) Application of ANS

20 mg/L ANS spray was obtained from Anson Nano-Biotechnology Co., Ltd. (Hong Kong, China) and was used according to the manufacturer's instructions. Before ANS application, the surgical incision was gently cleaned with sterile saline and dried using sterile gauze to remove debris and reduce potential contamination. Approximately 3 – 5 mL of ANS solution was evenly sprayed onto the cesarean incision site to ensure complete coverage of the wound surface twice daily immediately before red light therapy for 4 weeks.

(3) Application of RLTA

Red-light therapy was administered using CQ 27 red-light therapeutic instrument (Chongqing Haifu Medical Technology Co., Ltd., Chongqing, China). The treatment device was positioned approximately 30 cm from the surgical incision site with the output power of 12 W, power density of 80 mW/cm², and wavelength of 640 nm. The diameter of the illuminated spot was 13.8 cm, ensuring that the entire incision area was covered during treatment. Each treatment session lasted 20 – 30 min, and the therapy was administered twice daily in the morning and evening for 4 weeks.

During the post CS surgery interventions, meticulous observations of incisional healing were conducted with documentation of healing duration, quality, and scar formation. By comparing data from both groups, the efficacy of ANS combined with RLTA based on CNI for CS incision healing was evaluated.

Assessment of incision healing

The incision site was classified as grades A, B, or C on approximately 5 to 7 days after surgery based on the degree of healing. Grade A indicated good incision healing with no adverse reactions, which indicated that there was no inflammation at the incision site and no symptoms such as redness, swelling, hardness, or hematoma. Grade B suggested a certain degree of inflammatory reaction at the incision site, possibly accompanied by symptoms such as redness, swelling, hardness, or hematoma, but no pus formation. In this case, close observation of incisional changes was required, and appropriate measures were taken, including applying a cold compress or using anti-inflammatory medication. Grade C indicated that the incision site had become purulent, requiring either incisional drainage or open incisional treatment.

Assessment of scar formation

Scar formation assessment was primarily focused on the scar appearance and the score of Vancouver scar scale (VSS) system. The scar appearance assessed the degree of scar formation by examining the external characteristics of the scar including color, shape, size, and height. The VSS was used to evaluate scar severity [28], which assessed factors of scar color, height, hardness, and degree of contraction with a 10-level scale. A higher score indicated a more severe scar.

Assessment of incision pain

Incisional pain was graded based on patients' self-perceived pain and pain levels. Within this grading system, level 0 indicated no pain sensation with the patient experiencing no discomfort from the incision site. Level I indicated slight discomfort that the patient could tolerate without significantly affecting normal activities or sleep. Level II denoted pronounced pain that was quite intolerable, requiring the patient to take pain-relieving medication. The pain negatively impacted on the sleep quality. Level III indicated rising pain that became intolerable, requiring the administration of strong analgesics, which significantly interrupted patients' sleep.

Statistical analysis

SPSS 26.0 (IBM, Armonk, NY, USA) was employed for statistical analysis of this study. The mean ± standard deviation (SD) was used to present the distribution of continuous variables. Student t-test was used to assess differences between and intra groups. For categorical data, distributions

Table 1. Comparison of VSS scores in different groups.

Group	Vancouver Scar Scale (VSS) Level (cases)										
	L0	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Ctrl group	0	2	2	14	13	16	2	1	0	0	0
Exp group	1*	6*	10*	15	12	5*	1*	0*	0	0	0

Note: * indicated a significant difference ($P < 0.05$) between groups.

were presented as n (%), and chi-square (χ^2) test was used to compare the difference between groups. *P* value less than 0.05 was considered as statistically significant.

Results and discussion

Comparison of incision healing time in different groups

The incisional healing time in postpartum women after different interventions showed that the application of ANS combined with RLTA in the Exp group significantly shorter than that in Ctrl group with the average of 14.8 ± 1.9 days in Exp group comparing to 23.5 ± 2.8 days in Ctrl group for complete wound healing ($P < 0.05$) (Figure 1), which represented a 37% reduction in healing time, indicating that the combined application of Anson nano silver, red light therapy, and comprehensive nursing intervention substantially accelerated post-cesarean wound healing compared with standard care alone. The results might be attributed to the antibacterial and anti-inflammatory properties of nano silver, which reduced the risk of infection and inflammatory responses, promoting incisional healing [13-17]. Moreover, RLTA is widely recognized for its role in stimulating cell proliferation and repair, thereby accelerating incisional healing [20-24]. Therefore, the combined application of ANS and RLTA might promote incision healing through multiple mechanisms.

Comparison of scar formation in different groups

The VSS scores of postpartum women after different interventions showed that about 64% of the Exp group achieved VSS scores of 0 - 3 (minimal scarring) compared to 36% in the Ctrl group ($P < 0.05$), while 38% of the Ctrl group scored at VSS levels 5 - 7 (moderate to severe scarring) compared to only 12% in the Exp group ($P < 0.05$). The Exp group demonstrated a higher proportion of lower VSS scores than Ctrl group, indicating superior scar quality ($P < 0.05$) (Table 1). These findings indicated that the combined intervention involving ANS, RLTA, and CNI effectively reduced scar formation severity following cesarean section. Scar formation is a common complication following CS that may lead to pain, functional impairments, and cosmetic concerns. By promoting incisional healing and minimizing inflammatory reactions, the combined approach of ANS and RLTA might reduce scar formation and improve overall quality of life for patients [13, 16, 21, 24].

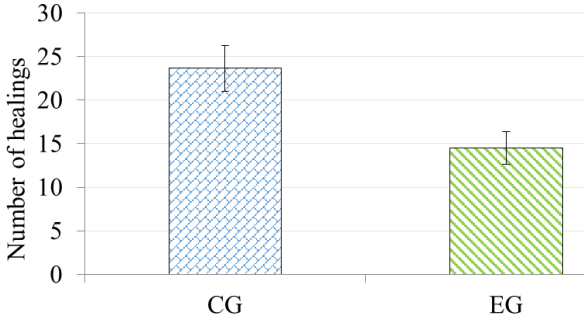

Figure 1. Comparison of incisional wound healing time in different intervention groups. **CG:** control group (Ctrl). **EG:** experimental group (Exp).

Comparison of incision pain level (IPL) in different groups

The comparison of IPL in different intervention groups demonstrated that the number of individuals with Level 0 pain in the Exp and Ctrl groups were 26 and 7 ($P < 0.05$), while 13 and 9

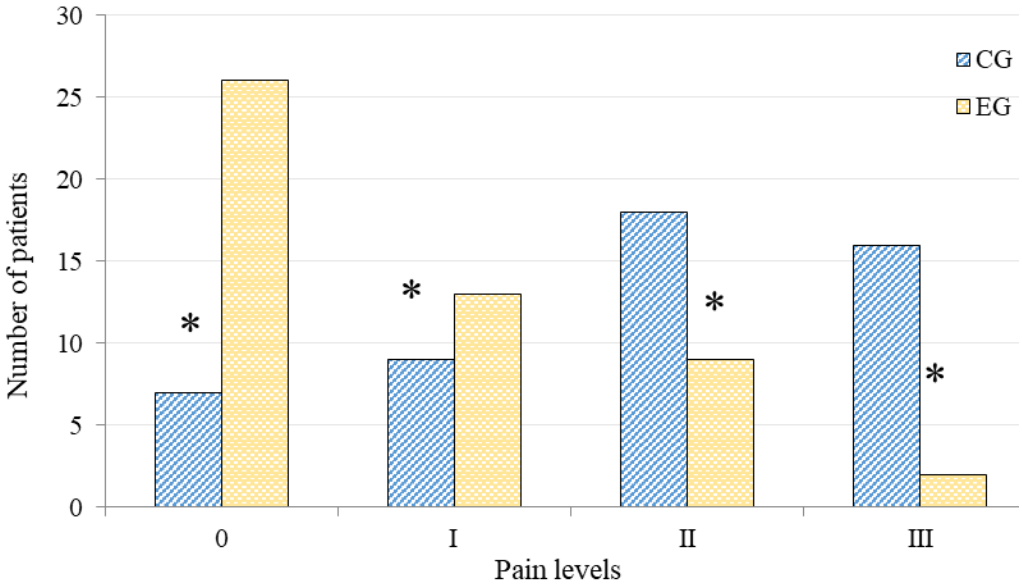

Figure 2. Comparison of IPL in different groups. *: indicated a significant difference (P<0.05) between groups.

patients reported mild pain, respectively (P < 0.05). However, Ctrl group reported more moderate and severe pain than Exp group with 18 and 16 in Ctrl group compared to 9 and 2 in Exp group, respectively (P < 0.05) (Figure 2). The results indicated that the combined intervention effectively reduced postoperative pain intensity in post-CS patients.

Comparison of the incision healing level (IHL) in different groups

The IHL of postpartum women in the Exp group was markedly higher than that in the Ctrl group with 72% of grade A healing in Exp group compared to 36% of grade A healing in Ctrl group (P < 0.05). The grade B healing in Exp group was 26%, while that in Ctrl group was 42% (P < 0.05). Further, the grade C healing showed 2% in Exp group and 22% in Ctrl group (P < 0.05) (Figure 3). These findings demonstrated that the combined intervention significantly improved overall wound-healing outcomes in post-cesarean patients.

Nano silver exhibits robust antimicrobial activity, effectively inhibiting and eliminating bacteria, viruses, and fungi [29, 30]. RLTA promotes wound healing and tissue repair while reducing inflammatory responses [31, 32]. The combined application of nano silver and RLTA enhance the antimicrobial effect, thus shortening the duration of infection treatment. Red light therapy (RLT) enhances blood circulation, thereby improving oxygen and nutrient delivery and accelerating the wound-healing process. Nano silver suppresses wound infections, reducing complications during the healing process. The combined use of nano silver and RLT expedites wound healing and reduces scar formation. Red light therapy stimulates nerve endings, facilitating the release of endogenous pain-sensitive substances and providing pain relief. Nano silver exerts anti-inflammatory effects, reducing inflammation and associated pain. The synergistic use of nano silver and RLT provides improved pain and inflammation relief.

Conclusion

Currently, only a few studies have explored the combined application of both CNI-based ANS and RLTA treatment methods. The results of this study demonstrated that CNI-based ANS combined with RLTA significantly affected post-CS incision healing and scar formation by

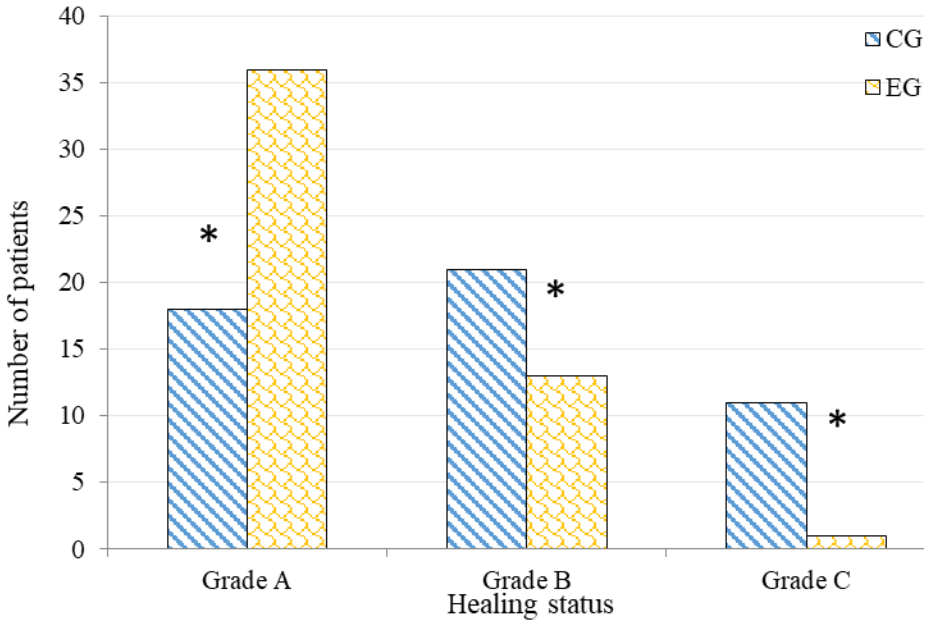

Figure 3. Comparison of IHL in different groups. *: indicated a significant difference (P<0.05) between groups.

facilitating incisional healing and reducing inflammatory responses, which might improve postoperative outcomes and overall patient quality of life. However, there remained several limitations that needed to be addressed, which included that the sample size was relatively small. The study only examined short-term effects, while long-term effects remained unclear. Further, this study focused exclusively on incision healing and scar formation following cesarean sections. The incisions from other types of surgeries had yet to be explored. Future research should focus on large-scale, long-term impact of therapy to validate these findings and assess the durability and the applicability of this treatment method across different types of surgical incisions. The findings of this research suggested that integrating ANS and RLTA based on CNI held promise for promoting post-CS incisional healing and mitigating scar formation. The multifaceted mechanisms underlying these effects warranted further exploration and validation in a broader clinical context.

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