

BASIC SCIENCE

Airborne particulate concentration during non-thermal nano-pulse stimulation wart clearance is negligible compared to thermal modalities

Edward V. Ross¹  | James Newman² | Jayachandran Ravichandran³ | Richard Nuccitelli⁴ 

¹Dermatology, Scripps Clinic, San Diego, California, USA

²Premier Plastic Surgery, Palo Alto, California, USA

³Clinical Group, Pulse Biosciences, Hayward, California, USA

⁴Biology Group, Pulse Biosciences, Hayward, CA

Correspondence

Richard Nuccitelli, Biology Group, Pulse Biosciences, 3957 Point Eden Way, Hayward, CA 94545, USA.
Email: rnuccitelli@pulsebiosciences.com

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Abstract

Objectives: As clinicians continue to implement safety protocols amid the global pandemic, considerations to mitigate potential viral transmission of airborne particulates (plume) generated from certain dermatologic procedures are of growing interest. This study intended to measure the change in airborne particulate matter using a non-thermal energy modality called nano-pulse stimulation (NPS) and compare levels of concentration to common thermal modalities (CO₂ laser and electrocautery). NPS is a new non-thermal modality that applies nanosecond pulses of electrical energy to induce regulated cell death in cellular structures while sparing the surrounding acellular structure of the dermis.

Materials and Methods: The study used a Condensation Particle Counter during four types of dermatologic procedures: (1) using non-thermal NPS for the clearance of cutaneous, nongenital warts; (2) an electrocautery treatment of warts; (3) a CO₂ laser for facial resurfacing; and (4) an electrocautery procedure for a facelift. Four subjects and a total of 11 warts were treated with NPS while a particle counter was used to detect the average particles per cubic centimeter once per second. The same particle counter was used, for comparison, during a wart removal procedure using electrocautery for comparison, and for control, during a skin resurfacing procedure with a CO₂ laser and a facelift in which electrocautery was used.

Results: Only one of the 11 NPS wart procedures generated any detectable change in the particulate concentration and that change was negligible in comparison to the increase in particulate concentration measured during the CO₂ laser resurfacing and the electrocautery use during a facelift procedure.

Conclusions: Procedures using non-thermal NPS technology do not generate significant plume when applied to eliminate warts, suggesting it is unlikely that this new energy modality would release viral DNA into the air.

KEYWORDS

electrocautery, face lift, laser, nano-pulse stimulation, particulate matter, plume, wart

INTRODUCTION

Many dermatologic procedures using thermal energy produce an aerosolized byproduct known as surgical plume which poses risks associated with exposure to

the dermatologist, staff, and patient. Plume content has been shown to include undesirable components such as acetonitrile,¹ and when warts are being treated viral DNA has been detected in the plume.^{2–5} During these past months of the Covid-19 pandemic, this

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mode of transmission of the viral DNA is especially concerning.

There have been contradictory results assessing the effect of plume generated by lasers. A CO₂ laser with either plume suction or argon plasma coagulation has been shown to have low risk of human papillomavirus (HPV) spread during the treatment of condylomata acuminata.⁴ However, when it is used in continuous mode, a power density of 500–2000 W/cm² was found to spread HPV DNA during treatments.³ The treatment of plantar warts using CO₂ lasers and electrocoagulation has also been shown to produce plume vapors that were positive for HPV DNA and the HPV DNA concentration was higher in the CO₂ laser treatments when compared to electrocoagulation.² Electron microscopy and southern blot analysis confirmed the spread of HPV and bovine papilloma virus (BPV) through plumes when the continuous wave-mode power density of 666 W/cm² was implemented in the treatment using CO₂ laser.⁵ Laser plumes of aerosolized infectious material such as BPV and HPV from CO₂ laser exposure transmit the disease from the plumes if constant suctioning through a filter system from the procedural area is not carried out.⁶

Nano-pulse stimulation (NPS) is a non-thermal technology that uses ultra-short pulses of electrical energy to generate nanopores in the plasma membrane as well as organelle membranes of cells of the targeted area. NPS technology is delivered by a console-based, handheld applicator (CellFX[®] System; Pulse Biosciences). The application of the appropriate number of NPS pulses will trigger the activation of the endogenous regulated cell death pathway that is present in all cells. This technology has already been used to treat dermatologic conditions such as seborrheic keratoses,⁷ sebaceous hyperplasia,⁸ and cutaneous nongenital warts.⁹ Due to the non-thermal nature of the ultra-short electrical pulses used in NPS, it is very unlikely that they would generate any particulate matter upon application to the skin. However, one way to measure this is to place a very sensitive particle counter in the treatment region during delivery of NPS pulses. This was done during the procedures on eleven warts on the hands and feet of four subjects. Here we show that an important advantage of non-thermal NPS technology is the absence of the release of any plume or particulate matter during the procedure.

MATERIALS AND METHODS

Equipment

The particle detector was a condensation particle counter (Model 3007; TSI Inc.) held within 18 inches of each procedure location. The CO₂ laser was a Mixto Pro continuous mode laser used for skin resurfacing (Lasering USA) and the electrocautery device used on the facelift was the Megadyne[™] Electrosurgical Generator (Ethicon) and that used for the wart removal was Bovie Aaron “hyfrecator”

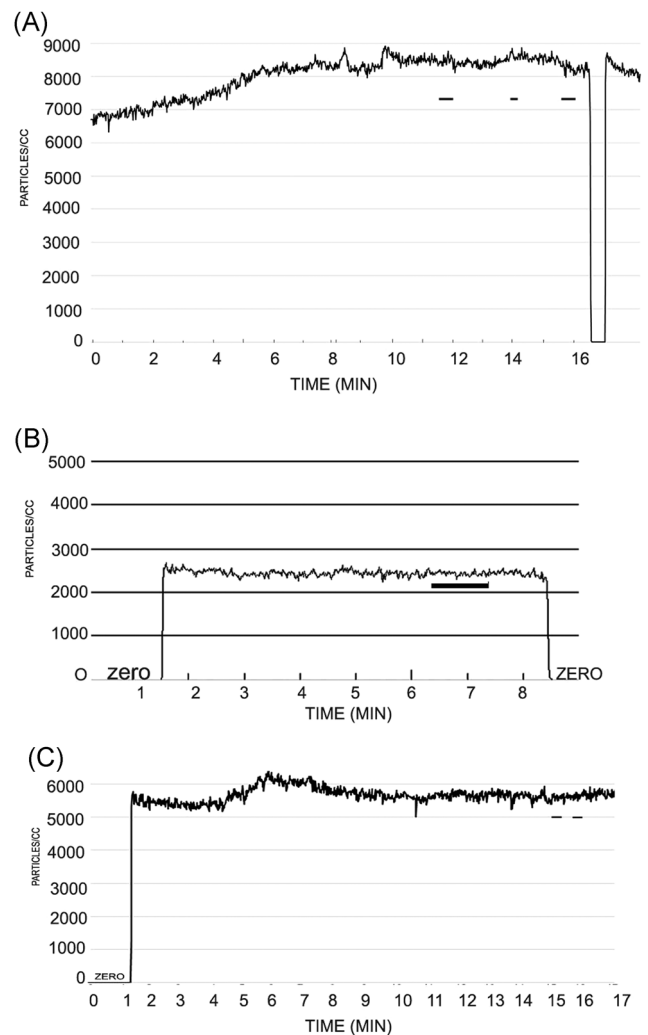


FIGURE 1 The time course of particle density measurements during four different wart treatments with NPS. (A) Three treatments on the foot; 1st treatment was a plantar wart on the palm sole with a 7.5 mm tip, 2nd treatment was on middle toe with a 7.5 mm tip and the third treatment was on the fourth toe with a 10 mm tip. After 16 min the HEPA filter was briefly placed on the input port to check instrument function; (B) Plantar wart on the palm sole of a foot treated with a 10 × 10 mm applicator; (C) Two warts were treated on the anterior hand. The first was on the middle finger using a 2.5 mm tip and the second as on the same finger with a 7.5 mm tip. NPS, nano-pulse stimulation

(model 940; Bovie Medical Corp.). The application of non-thermal NPS was delivered by the CellFX[®] System (Pulse Biosciences). The applicator is composed of two or three parallel rows of microneedles that are inserted into the epidermis and dermis surrounding the wart, allowing ultrashort pulses of electric energy to pass through the wart to trigger regulated cell death.

RESULTS

Eleven warts were treated with NPS and the application time of six of these procedures are indicated on the particle counter recordings shown in Figure 1. A HEPA

filter was placed on the input during the zero particle levels indicated. The room air typically registered 2500–8000 particles/cc as a baseline. The instances of NPS delivery are marked as horizontal bars beneath the

output of the particle counter. None of instances where NPS was delivered registered any significant increase in particle concentration during or after the NPS procedure.

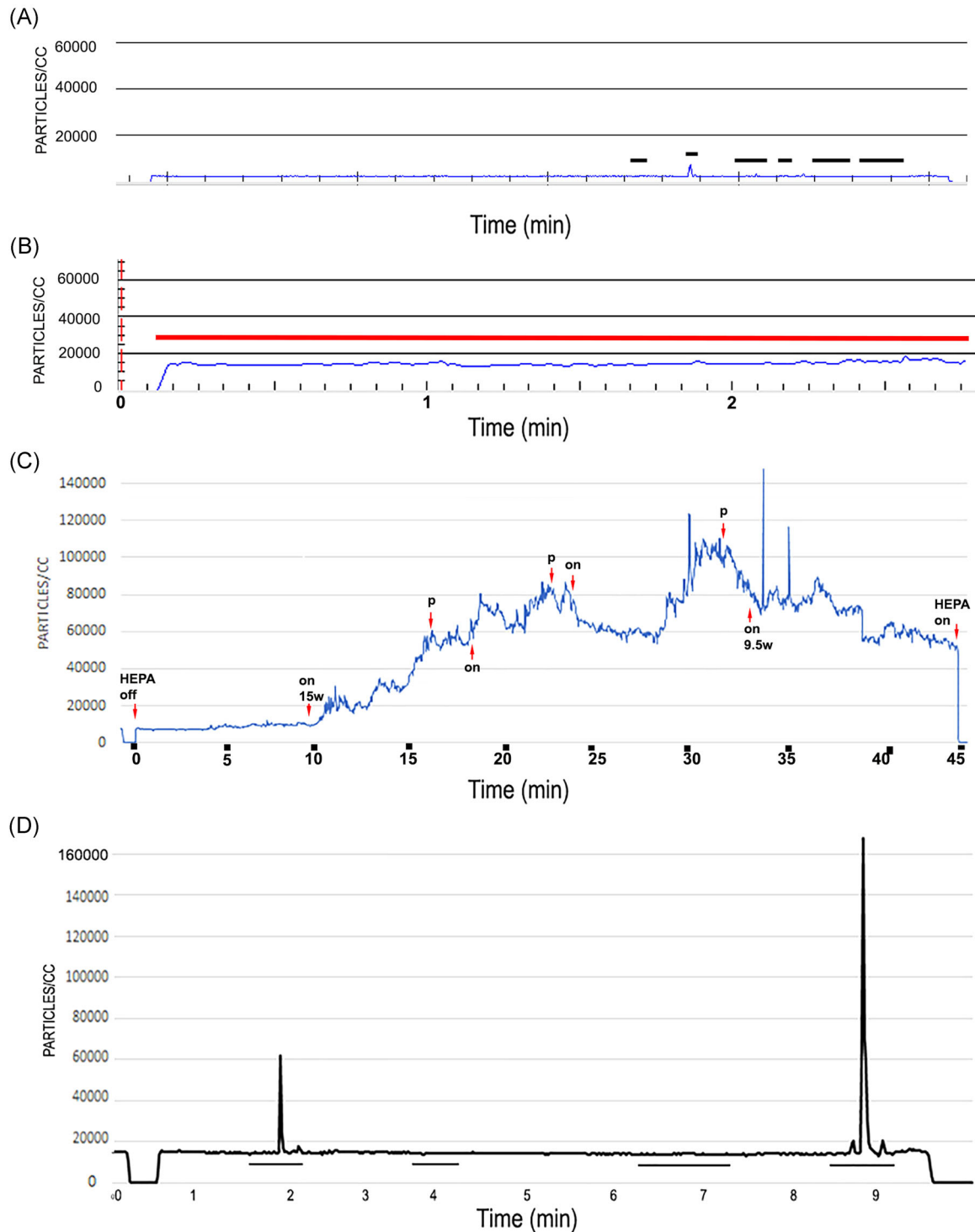


FIGURE 2 Particle density measurements plotted on similar density scales during skin treatments to simplify comparison. (A) NPS treatments of six warts. Bars indicate times NPS treatments were applied; the second treatment generated the only significant increase in particle density that we have detected with a peak of 7000 particles/cc; (B) Hyfrecator treatment of a wart on the back. Red bar indicates time at which hyfrecator was activated and it started before the particle detector was turned on; (C) CO₂ laser resurfacing of facial tissue. “On” times are marked by arrows, “p” indicates a pause in laser application; (D) Bovie treatments during a facelift procedure. Black bars indicate times Bovie was activated. NPS, nano-pulse stimulation

As a positive control, the particle counter was used during two electrocautery procedures and one CO₂ laser skin resurfacing procedure (Figure 2B–D). For comparison six NPS wart treatments are plotted on a similar particle density scale (Figure 2A). The only significant particle density increase detected near NPS procedures is the second treatment in Figure 2A which briefly peaked at 7000 particles/cc. In contrast, when a wart was treated with a hyfrecator the particle density quickly rose to 14,000 particles/cc and remained at or above that level during the entire procedure (Figure 2B).

The highest particle levels were recorded during a CO₂ laser facial skin resurfacing procedure at power levels ranging from 15 to 20 W with a 180- μ m spot size in chopped continuous wave mode in which the particle levels rapidly rose to 100,000 particles/cc and above. These high particle concentrations remained elevated during the entire procedure despite the use of a surgical smoke evacuator held within 3–4 inches of the surface of the skin where the laser was applied.

The final example is an Electrosurgical Generator device used surgically during a facelift procedure. This device did not generate increases in particle density at every use, but could generate the highest peaks above 160,000 particles/cc.

DISCUSSION

It is clear from these particle density measurements that the lowest levels of particle generation were observed during the NPS wart treatments. In fact, only one of the 11 NPS procedures generated any detectable particles and that corresponded to a single coronal discharge due to the lack of sufficient contact gel. This very low particle generation is due to the non-thermal mechanism of NPS that does not use heat but instead generates water-filled nanopores in the cell and organelle membranes of the targeted zone which initiates the endogenous regulated cell death pathway present in most cells. This contrasts with all three of the other ablation modalities which use heat to burn off the epidermis or skin lesions, generating significant particulate matter, or plume. This plume carries noxious chemicals into the air and poses a high risk of spreading of viral DNA.

NPS is a relatively new energy modality so it remains to be seen if it will replace the CO₂ laser or radio frequency devices in some skin procedures. However, its safety and efficacy at clearing other cellular lesions such as sebaceous hyperplasia and seborrheic keratosis suggests that non-thermal skin resurfacing with NPS should be possible by using applicators appropriate to the problem area.

In conclusion, airborne particle density measurements have confirmed that NPS procedures do not release significant particles into the room air and should therefore offer a safer alternative to modalities that use heat to resurface skin or burn off lesions.

ORCID

Edward V. Ross  <http://orcid.org/0000-0002-0923-3578>

Richard Nuccitelli  <http://orcid.org/0000-0002-1089-3194>

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