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PLASMA MEDICINE FRONTIERS - ENERGY BASED TREATMENT MODALITIES FOR NEXT CENTURY- THE MEDICAL REVOLUTION HAS BEGUN

Clinical Research

Prof Dr Pradeep Kumar Radhakrishnan* MS, MCh CTVS AIIMS, Postdoctoral fellow CTVS and ECMO, Chief Division of Cardiothoracic Surgery, GIMSR Gitam University. *Corresponding Author

Gayathri Ananyajyothi Ambat Student GIMSR, Gitam University.

Prof R M Rao Gitam School of Science

Dr Nazeema Nazer TMRI, MD D&V.

Dr Nihaz Nazer MS, Mch CVTS, Jayadeva Institute

Prof Y A Nazer Mch CTVS AIIMS, Director Travancore Heart Institute.

KEYWORDS

APPJ - atmospheric pressure plasma jet, RS- reactive species, DBD- dielectric barrier discharge, ECIS- electrical cell substrate impedance sensing, CAP – cold atmospheric plasma,LTP Low temperature plasma, PAW -Plasma activated water, PAM- Plasma activated media ,PAL Plasma activated liquid.

INTRODUCTION

Plasma medicine is fast emerging as an interdisplicinary research domain with vast clinical potential- essentially is a conglomeration of plasma physics, chemistry, biomedical science and engineering. The less dense forms of plasma at lower temperature are interrelated to auroras and stellar and solar winds.

DISCUSSION:

Plasma medicine is actually a conglomeration of plasma physics, clinical medicine and life sciences. This currently is a vivid example of interdisciplinary interaction for social benefit. An ionized gas which is charge neutral is plasma. One of its early recognised uses is sterilisation of biomaterial surfaces. Low temperature sources (LTP) that operate at atmospheric pressure can be used for medical applications. Burns would result with temperatures above 50 degree C. Resistive barrier discharges can be used for DC applications {1}.50-60 Hz power sources are used. Here human body can serve as one of the electrodes. Bacterial inactivation {2}, skin disorders and cancer treatment {3} are early promising options. AC or pulsed power supply sources are used. Research and clinical studies currently use the following CE certified devices.

1.Atmospheric pressure plasma jet kINPen® MED (INP Greifswald/neoplas tools GmbH, Greifswald, Germany)
2.Dielectric barrier discharge source PlasmaDerm® VU-2010 (CINOGY GmbH plasma technology for health, Duderstadt, Germany)
3.SteriPlas (Adtec Ltd., London, United Kingdom)

APPj- Atmospheric pressure plasma jets use gas to deliver plasma to tissues. Helium or Argon can be used for this purpose. Maximum reactive species generation occurs at the site where room air diffuses into the noble gas {4}.Di electric barrier discharges can be used to limit the current, but not in all devices. Other methods use a high voltage pin electrode at the centre of the quartz tube. Ionization waves mix with the ambient air prior to delivery. These have been termed as plasma bullets {5}. Direct contact with tissues delivers more reactive and charged species. Two planar jets with gas flow that when used simultaneously can be used to cover larger surfaces and simplifies usage {6}.Three major application fields include normothermic atmospheric pressure directed plasma therapy, plasma assisted modification of bio-relevant surfaces and plasma based sterilisation. Only normothermic atmospheric pressure types are suited for direct tissue application. The effects are due combination of electromagnetic radiation, reactive and charged species and primary radicals. The cells with greater oxidative stress are eliminated. Electroporation allows more radical species to enter the cells also. This knowledge can use nanoparticle for delivery of drugs by energy dependent and independent mechanisms of endocystosis {12}. The additional component of systemic immune response stimulation also may be involved {13}.The accelerated endocystosis is via clathrin dependent membrane repair pathways, with lipid peroxidation and cell membrane damage {14}. APPj treatment protects against hypoxia induced injury, glucose deprivation and attenuates hypoxia microenvironment using an electrical substrate impedance sensing system. Argon plasma coagulation finds role in surgical applications {7, 8}. A two-minute CAP treatment, for example, has been shown to be effective against a variety of bacteria including important skin and wound pathogens such as Escherichia coli, group A Streptococcus, Methicillin-resistant Staphylococcus aureus (MRSA), and Pseudomonas aeruginosa, suggesting positive effects of CAP on wound healing. It aids in chronic ulcer healing {9, 10}.Actinic keratosis,ichythosis, scar management, acne rosacea, warts and androgenic alopecia (indirect plasma treatment) can be treated with plasma {11}.Role of nitric oxide released by plasma in wound healed was reported earlier by Russians {15} with augmented fibroblastic proliferation and enhanced phagocytosis. Cold plasma has found application in neuro differentiation and protection as well as anti cancer treatment like glioblastoma treatment {16}, selective differentiation of neuronal stem cells into neurons {17} and brain injuries, ischemia or infarction {18}.The potential use of CAP for cancer treatment has also been assessed in vitro and in vivo in several other nonskin cancer entities including breast cancer, pancreatic carcinomas, glioblastoma, colorectal carcinoma, and neuroblastomas{20,21,22,23,24}.Emerging new applications are noted in dental sciences too. Plasma activated liquids that have been used include water to make plasma activated water (PAW) and biological culture media to make plasma activated media (PAM).

CONCLUSIONS

Essentially multidisplinary in its evolution plasma medicine heralds the way treatment modalities would evolve in future. Applications have grown and diversified into various subspecialties in medicine and newer mechanisms of action are being discovered leading to further enhanced applications. Direct molecular transportation of particles, that are species specific and with tissue propagation for desired medical or biological effects is an immediate reality that we are faced with. Energy based dry technologies for treatment should be envisaged for space travel as human race is on the verge of colonisation of other planets too.

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