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A REVIEW ON WATER BOLUS STRUCTURE INTEGRATION FOR NON-INVASIVE HYPERTHERMIA TREATMENT

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ABSTRACT

This paper presents a review of hyperthermia on a modified water bolus structure for breast cancer. Hyperthermia is an alternative treatment for cancer, which uses high heat to treat a cancer patient. Because of certain limitations, especially difficult to control focus position distance on the treated tissue has contributed to the low success rate of the treatment. In addition, excessive skin burn problems and adverse health effects on surrounding healthy tissue could occur as a result of high temperature applied on the skin and wide area of unwanted hot spots. Proper design on hyperthermia applicator can assist in reducing unwanted hot spots in the vicinity area while improving the focus position distance on the treated tissue, simultaneously. Meanwhile, massive skin burns can be overcome with the addition of water bolus. Based on previous research on water bolus, various designs have been investigated. However, further research needs to be carried out in order to provide more significant results on different stages of cancer. Therefore, in this research, a water bolus is investigated further by taking into consideration several factors to optimize the function of water bolus as a cooling system. Hence, it may reduce unwanted hot spots, minimize skin burn problem, while maintaining the required focus position distance on the treated tissue during the hyperthermia execution procedure. A deductive and inductive literature review approach is used to determine the research gap of current research on water bolus addition to hyperthermia procedure. A rectangular water bolus structure was used the most in hyperthermia research as it can be modified further, and it has the largest covered area for reducing unwanted hot spots on

surrounding healthy tissue. The comparison analysis of different types of water bolus is presented.

Key words: Non-Invasive, Hyperthermia, Water bolus, Cancer treatment, Skin burn.

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1. INTRODUCTION

Breast cancer is the most prevalent form of cancer affecting women globally and the leading cause of death among women in the world [1]. Researchers and scientists from all over the world have involved with the various method through simulation, experimental and clinical trials to improve the existing procedure to be more convenient and come out with the more effective cancer treatments [2],[3],[4]. Hyperthermia which also known as thermal therapy or thermotherapy, has attracted the interest of many researchers to be used as an alternative method to treat breast cancer patients [2],[5]. During hyperthermia treatment, the temperature is elevated between 40℃ - 45℃ where the range of the heat temperature can kill and destroy the cancer cells [2],[6]. Hyperthermia can be applied either invasive or non-invasively [5]. The invasive method is where the probe is inserted into the patient body, while non-invasive is where the applicators are applied externally or placed outside of the patient body. For non-invasive hyperthermia treatment, the applicator used is either Ultrasound (US) or Electromagnetic (EM) waves as a source of heating techniques [7]. Each of those heating techniques has its own advantages and disadvantages and selected based on the function or objectives of the treatment given.

Hyperthermia is safer than the traditional method and can enhance the efficacy of the conventional method [8]. However, previous research paper mostly discussed on the skin burn problem and not many papers discussed on unwanted hot spots obtained from undergoing the treatment [9],[10]. Hyperthermia treatment uses in various cancerous cells have been studied. Rectangle shape, deionized, or distilled water bolus is a preferred shape and liquid used for tissue cooling [4],[11]. Apart from that, the integration of water bolus to the applicators is also to create good impedance matching between the applicator and patient body [5].

In 2019, there are several publications on new material that have the same purposes of reducing skin burn problems. In the study of A.Ghasemlouy and S.Rajebi [2] a little, lightweight and wideband antenna has been designed. The purpose of the research is as the replacement of water bolus using the silicon layer, which can help decrease the percentage of burns to a minimum [2]. Another published research paper by Hana Dobsicek Trefina and Anna Storm [3] found a new way as alternative tools to by using hydrogels to improve heat delivery [3]. Most published hyperthermia cancer treatment use distilled or deionized water as water bolus, which is well known can help to solve skin burn problem.

Several limitations encountered by the previous researcher, such as the optimization of temperature to be used maximally within and at the restricted area in the target cancerous cells, is still a huge challenge in hyperthermia methods [12]. Different shapes of antennas were employed in hyperthermia for temperature increase purposes [13]. Finding the optimal temperature setting is considered difficult because available sources share the different settings, and some published papers provide limited information [14]. Previous clinical publications faced a challenge to control applicator powers, and water bolus temperature due to tissue homogeneities in every patient are time-varying and non-linear [15]. Therefore, this