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Safety Concerns Associated to Microbial Infections in Therapeutic Ultrasound

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Abstract:

Therapeutic ultrasound is commonly used in physiotherapy healthcare for treating any sort of pain and stimulating tissue repair. Ultrasounds are sound waves with high frequency that are produced by a transducer which imparts certain effects on the human body. It is commonly used for treating subjects with the following conditions: carpel tunnel syndrome, frozen shoulder, tendonitis, ligament injuries, joint tightness, etc. The device and the gel used for the treatment might act as fomite as they are in direct contact with the patient skin, possibly acting as a source of microbial contamination. The transducer head and the gel should be handled cautiously in order to avoid cross contamination. There is a lack of literature reporting the safety concerns related to transmission of infections to the subject during the course of ultrasound therapy. This article fundamentally provides an outline about the possibilities of cross contamination among the patients undergoing therapeutic Ultrasound

Keywords: *Therapeutic ultrasound, ultrasound gel, transducer, microbial contamination.*

Individuals recuperating from injuries and surgery go through a physiotherapy rehabilitation program performed in healthcare centers to reinstate normal body function. [1] The risk of physiotherapists being exposed to nosocomial infections is common as they interact with a wide array of patients. The patients receiving physical therapy are mostly the elderly and people with life threatening conditions, thus they would require proper management.[2, 3] Therapeutic ultrasound is one of the treatment methods employed by physiotherapists that aids the patient to retain their normal range of motion after going through medical proceedings.[4] In the 1930s the importance of ultrasound in medical field came into light [5]. Over the years, scientific progress has allowed better ways of treating Meniere's disease efficiently by destruction of the vestibular nerve and in Parkinson's disease with targeted ultrasound for localized tissue destruction in the brain. [6, 7] Therapeutic ultrasound for physiotherapy was initiated by the 1970s, and continuous advances have been accomplished towards improval of treatment. Currently, ultrasound therapy serves as a vital approach for treating multiple clinical conditions.[8]

Globally, therapeutic ultrasound is one of the most commonly applied treatment method in physiotherapy according to a recorded survey.[9-15] During treatment using therapeutic ultrasound, the head of the ultrasound transducer comes in direct contact with the skin. The use of a couplant medium allows relative transmission of the sound-waves into the deep tissues. The gel used in the treatment is stored in containers that may come in contact directly with the patient or the ultrasound head. This could transmit the bacteria to the subjects as the gel container is reused during each treatment sessions and there is a chance of cross contamination due to improper handling of the gel. Both the head and the gel container can be the reservoirs for pathogens if used without caution. [16,17] Both in-patient and out-patient undergoing therapeutic ultrasound are likely to be at a risk of nosocomial infections.[4, 16, 17, 18] The most common bacterial infections associated with ultrasound gel contamination are known to be caused by organisms such as *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella spp, Burkholderia spp, etc* [17, 19, 20] According to a research by the United States, the rate of methicillin-resistant *Staphylococcus aureus* (MRSA) infections increased from 2.4% to 54.5%.[21] The rate of MRSA infections has decreased over the time. But in overall reported cases recently there are only few individuals affected by MRSA in hospitals and clinics.[22] Community associated MRSA (CAMRSA) affects the a large population and is of greater significance, but is under-reported to the CDC.[23] The Australian Physiotherapy Association has put forward certain recommendation regarding the cleaning of the

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ultrasound equipment with 70% alcohol after each sessions of treatment to decrease the rate of microbial infection. [24] As there are no proven reports about the efficacy of these guidelines in reducing the microbial load on the ultrasound equipment, they should only be considered as recommendations for disinfection. [4] Revolution in therapeutic ultrasound has lead to establishment of novel treatment methods in laboratory that could be further implemented in healthcare centers. [25] The objective of this review is to highlight the safety concerns related to microbial infections during therapeutic ultrasound.

Therapeutic Ultrasound and its effects

Ultrasound's ability to interact with tissues has been recognized since many years that it could produce biological changes. [26] The improvement was under development in order to increase the efficiency and therapeutic effect of the therapeutic ultrasound. Therapeutic ultrasound is divided into two categories based on its intensities, low-intensity and high-intensity applications.[27]

Ultrasound therapy in general has pros and cons and thus the clinician should be aware of the tractable safety issues.[25] The vibrational motions of ultrasound have been shown to be efficient in increasing circulation that helps in breaking down any adhesion between muscles and its sheath that impair the range of movement.[28] Low intensity in ultrasound is used to activate physiological effects to the damaged tissue and to enhance the rate of some process such as drug transportation.[27] Therapeutic ultrasound is based on a number of power settings and comes from many manufacturers, but the concepts remain the same; the ultrasound system generates an electrical signal through crystals embedded in the ultrasound probe's head. The crystals vibrate at frequencies outside the range of human hearing (20 Hz to 20000 Hz) and create mechanical waves. This phenomenon is called as piezoelectric effect.[29]

Therapeutic ultrasound of high frequency is known to produce a wide range of biological effects mainly through two modes of action, thermal and non-thermal effects. [30, 31] Thermal effect is observed on continuous application of high intensity waves to deliver therapeutic ultrasound that result in dose- and time-dependent elevation of tissue temperature.[32-35] Biological tissues such as those with high collagen content and other fibre-containing proteins absorb the acoustic energy and are able to convert this into heat energy, thus increase the flexibility of the tissue and improve the blood flow further enhancing the mobility and healing due to the tissue heating. [36]

In contrast, non thermal effects of ultrasound either act through cavitation or acoustic streaming. [30, 31, 37] Cavitation is a result of the compression and successive decompression of microscopic gas bubbles embedded in the biological fluid by virtue of the mechanical pressure waves. The exposed tissue undergoes a repeating cycle of compression and rarefaction caused by the propagation of the ultrasound waves, which in turn causes the contraction and expansion of the microscopic gas bubbles. [31] Contrary to cavitation, acoustic streaming is the motion of fluids along the cell membrane in a single direction caused due to the pushing of fluid across the cell structures as a result of the mechanical pressure wave (ultrasound). 26, [30, 31, 37]

Transducers usually contain piezoelectric substances like quartz, Lead zirconate titanate or Barium titanate.[27] Typically, the method has an electrical signal generation base and a hand-held transducer. The transducer head is moved in a circular, overlapping or transverse manner on the patient's skin with the help of a gel over the area of injury. It is also used to treat conditions such as tendonitis, bursitis or any kind of pain.[25] For physiotherapy, ultrasound is usually applied directly on the patient's skin by using a thin layer of the coupling media/couplant, e.g. Aqueous gel or any sort of mineral oil. A variety of compounds can be included in the coupling medium that improves the treatment efficacy.[27] Ultrasound in also used for phonophoresis and ionophoresis that helps in administering or facilitating the entry of certain drugs like lidocaines and cortisols into the cells.[38]

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Concerns and Preventive Measures in Ultrasound Treatment

In tandem with the transition from immune-suppressed and high-risk patients to community-based care, the amounts of contamination detected on clinical ultrasonic systems suggest that physiotherapists be aware of the potential for ultrasonic contamination.[4] Studies show that disinfection of the ultrasound head with ethanol soaked paper can remove their bacterial contamination, but repeated disinfection causes ultrasound head to degrade.[39, 40] The disinfectant Protex, which is used in many countries, effectively prevents bacterial contaminations of ultrasound probes and is known not to degrade probes. It contains dimethyl ammonium chloride as a disinfectant agent, which is one of the quaternary ammonium compounds.[41, 42] The ultrasound head is most commonly used with a couplant called ultrasound gel that comes in direct contact with the skin during its application. If cleaning protocols are insufficient, microorganisms can contaminate the skin during direct contact. Microorganisms present include huge numbers of *Pseudomonas*, *Acinetobacter*, and *Rhodotorula* species. Many investigators have reported high levels of microbial contaminations through medical equipment's such as diagnostic ultrasound, stethoscopes, otoscopes, etc. [2, 43, 44, 45] In this background, the physiotherapists should compulsorily make sure to disinfect the probe head with 70% alcohol as recommended by Australian Physiotherapy Association. [24] Ultrasound gel bottle tips showed more contamination than the ultrasound gel. Ultrasound gel bacterial contamination may be reduced by applying bacteriostatic agents to the gel manufacturing process or by regular disposal of older gel.[46] One alternative to reduce potential bacterial infection in patients through therapeutic ultrasound is by storing the gel bottles in an atmosphere with controlled temperature well outside the optimal growth range of mesophilic bacteria.[1] While gels are often considered bacteriostatic due to methyl benzoate or parabens, one of the study revealed that ultrasound gel does not have anti-microbial activity and could serve as a medium for bacterial growth. [18] Recently a study has reported that nearly 80% of *S. aureus* which were placed on ultrasound heads in the gel were able to survive for an hour. [47] Contrary to this result, further research is warranted regarding the inclusion of antimicrobial agents in the gel against bacterial contamination and is highly recommended. Although the ultrasound gel bottle is not considered sterile, its contamination during production and packaging should be termed as a source of nosocomial infection. Implementation of sterile materials for the manufacturing of gel is strongly recommended in order to decrease the associated health risks, also maintaining sterility with regard to the containers used for storage of the gel. [41]

Conclusion

As there is a lack of literature reporting the safety concerns related to transmission of infections during therapeutic ultrasound, more focused studies are to be conducted to standardize the methods for isolation and detection of microbial load from the ultrasound equipment and the gels. Further investigations need to be designed to determine the survival frequency of microorganisms in the ultrasound head and the gel. Finally, physiotherapists should ensure the implementation of standard safety guidelines during the course of therapy to minimize the risk of cross-infections.

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