TRANSMISSIVITY OF SOME LOCAL COUPLANTS AND PHONOPHORETIC DRUGS

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ABSTRACT

This study was designed to compare the transmissivity of ultrasonic energy through Feldene gel, Bengay ointment, shea butter, and honey with that of Aquasonic gel. The subjects for the study were eight normal undergraduate students aged 21-24 years.

The pre-insonation skin temperature in the mid-anterior aspect of the subjects' thighs was recorded. The selected area was then insonated for two minutes using the continuous, direct contact method and the post-insonation skin temperature was recorded using a skin thermometer. The difference between the pre- and post-insonation skin temperatures was used as an index of transmissivity. The transmissivity of each of the studied couplants was compared to that of Aquasonic gel using the independent t-test. All the couplants were further compared using one-way ANOVA at $\alpha = 0.05$ level.

There was no significant difference between the transmissivity of the couplants though the transmissivity of all the studied couplants appeared to be higher than that of Aquasonic gel. It was concluded that honey could readily be substituted for Aquasonic gel based on its availability, therapeutic value and variation in temperature change close to that of Aquasonic gel.

Key words: transmissivity, phonophoresis, couplants

INTRODUCTION

Ultrasound is the propagation of pressure waves in a medium of frequencies which are above the normal ranges of human audibility, while ultrasound energy is the vibrational energy caused by these pressure waves.[1] It has, over the years, found an increasing application in many areas of medicine such that a study by Stewart identified physicians, osteopaths, podiatrists, nurses and physical therapists as typical users of therapeutic ultrasound.[2]

As ultrasound waves cannot travel through air, adequate transmission of the energy from the

sound head to the tissue requires a coupling medium. The functions of the coupling medium are to transmit ultrasound energy efficiently, eliminate air between the transducer and the tissue, and serve as a lubricant in contact applications.[3]

An ideal coupling medium according to Dyson[4] should not only have the acoustic properties of water but should also satisfy the following conditions: no bubbles or other reflective properties, gel-like viscosity for easy use, sterile, hypoallergenic, chemically inert, transparent, inexpensive and could probably also serve as a dressing for wounds.

The ultrasound generator (machine) usually comes with the manufacturer's coupling agent - a consumable item. With the economic downturn in Nigeria, the cost of replacing this gel has been escalating at such a rapid rate that many physiotherapy departments have not been able to replace their stock and this has prevented them from using their ultrasound generators. There is, therefore, a need to look inward for locally available substitutes which will meet the criteria cited above.

Phonophoresis or sonophoresis, which is the use of ultrasound to assist in the dispersion of medication into body tissue, is very important in the treatment of certain conditions. It is, therefore, essential to examine how readily the commonly used phonophoretic agents transmit ultrasound energy. The purpose of this study was to compare the transmissivity of honey, shea butter, Feldene gel and Bengay ointment as coupling agents to that of Aquasonic gel (a manufacturer's ultrasound coupling medium.)

METHODOLOGY

Subjects

Eight clinical undergraduate physiotherapy students (four males and four females) were recruited for the study. The subjects, who were aged 22.5 ± 1.1 years, all had normal circulation and cutaneous innervation, as ascertained through routine clinical evaluation (thermal sensation and pin prick tests) of the area to be insonated.

MATERIALS

a. An ultrasound therapy unit (MEDICI 3070) with a transducer head with an effective area of $5cm^2$ to generate the ultrasound energy
b. A skin thermometer (type TE 3) manufactured by Ellab Instruments, Copenhagen, Denmark to measure the skin temperature in degrees centigrade (°C). The thermometer operates on the principle of thermocouple and h measurement range of 16-46°C
c. A mercury thermometer to measure the temperature of the couplants
d. Coupling media - Aquasonic 100, Feldene gel, Bengay ointment, honey and shea butter
e. Five test tubes to hold the ultrasonic couplants
f. Other materials: a bowl, cotton wool, water, soap, towel, a delible marker

PROCEDURE

The rationale and procedure for the study were explained to each of the subjects and his or her informed consent was obtained. The subject was then comfortably seated and the anterior aspect of the thigh was exposed. This area was chosen because of its fairly regular contour and good blood supply. A circle with a 5cm radius was then

drawn on the mid-region of the anterior thigh, using a delible marker. Insonation was restricted to the area within the circle. The area of insonation was washed with soap and water and dried with the towel. The thermocouple was set according to the manufacturer's instructions and the initial skin temperature taken. Next, the ultrasound machine was switched on and tested in a bowl of water to ensure that its transducer was functioning.

All couplants to be tested were applied to the mid-region of the anterior aspect of the thigh. The procedure was carried out on both thighs, thereby enabling two couplants to be tested daily for each subject. Each subject had to make three visits to complete the study, and insonation took place at the same time each day, with the couplants maintained at a temperature between 24°C and 25°C.

The temperature of the couplant was maintained by immersing the test tube containing the couplant in a beaker of water kept at a temperature range of 24°-25°C. Temperature distribution throughout the soft tissue is known to depend critically on the temperature of the coupling medium.[5] The highest temperature near the bone is 21°C, while the highest temperature in the superficial tissues is 24°C or above. The temperature of the superficial tissues when measured with a skin thermometer (thermocouple) therefore gives an index of transmissivity of the coupling medium.

The continuous and direct contact mode of insonation was used, with the transducer head maintained in a continuous overlapping circular motion within the selected area of the thigh in order to avoid the dangers of static insonation. A frequency of 3Hz was used because at this frequency, ultrasound energy does not penetrate beyond the superficial tissues. This was done to ensure that the measurement of the superficial skin temperature with the thermocouple would be a true reflection of the transmissivity of the coupling medium. In all cases, the intensity of insonation was 1watt/cm^2, while the duration was two minutes.

TREATMENT OF DATA

The index of transmissivity of each of the couplants was calculated using the difference between the mean pre- and immediate post-insonation skin temperatures, as suggested by Sanya and Oluseye.[6] The temperature change with the Aquasonic (manufacturer's) gel was used as the standard value and the relative transmissivity of each of the other couplants was calculated as a percentage of this value. The data were presented using percentages and a bar chart, while an independent t-test was used to compare the transmissivity of each of the tested couplants and Aquasonic gel. The transmissivities of all the couplants were further compared using the one-way ANOVA with the significance level (α) set at 0.05.

RESULTS

Eight clinical undergraduate students (4 males and 4 females) with a mean age of 22.5 years (SD= 1.1yr) took part in the study. None of the subjects exhibited skin irritation or any other allergic reaction to any of the coupling agents.

The mean differences between the pre- and post-insonation skin temperature and the relative transmissivity of the couplants are shown in table

1. The temperature differences for all the tested couplants were higher than that of Aquasonic gel, with honey showing the highest difference. Aquasonic gel, showed the least variability (SD = 0.44) in mean skin temperature change followed by honey (0.65), Bengay (0.82), Feldene gel (1.04), and shea butter (1.16). Further, honey showed the highest relative transmissivity while Feldene gel showed the lowest (table 1).

Table 1. Skin Temperature Changes with the Couplants and Phonophoretic Agents

Couplant	Mean Changes in Skin Temp. Transmissivity	Mean Change Relative to Aquasonic Gel
Aquasonic gel	1.13 ± 0.44	-
Honey	2.21 ± 0.65	195.6
Bengay ointment	2.09 ± 0.82	185.0
Feldene gel	1.54 ± 1.04	136.3
Shea butter	1.64 ± 1.16	145.1

The independent t-test was also used to compare the mean differences between the pre- and post-insonation skin temperatures after the application of each of the tested couplants and the Aquasonic gel (table 2).

Table 2. Comparison of Transmissivity of Aquasonic Gel and Each of the Couplants

Couplant	t-value	p-value
Honey	1.23	>.05
Shea butter	0.89	>.05
Bengay	1.96	>.05
Feldene	0.75	>.05

t (critical) = 2.145

There were no significant differences between each of the tested couplants and the Aquasonic gel. Similarly, the one-way ANOVA (table 3) did not reveal any significant difference in the transmissivity of all the couplants tested.

Table 3. ANOVA for Comparison of All Couplants

Sources of Variance	SS	df	MS	F	P
Between Groups	6.24	4	1.5	2.14	>0.05
Within Groups	26.1	35	0.7		
Total	32.3	39			

F (critical) = 2.74

DISCUSSION

This study compared the transmissivity to ultrasound of some local substitute couplants and therapeutic gels with that of the manufacturer's Aquasonic gel. Unlike in previous studies,[3, 6-9] all the media tested showed non-significant, higher transmissivity than the manufacturer's couplant. The chemical components of the couplants and therapeutic gels studied could have partly accounted for the results.

Honey is known to contain 17.20% water[10] which is believed to be the best coupling agent in terms of acoustic properties as it reflects only 0.2% of the sound waves at the water-soft tissue interface.[4] This probably explains why honey exhibited the best transmissivity in this study. Bengay ointment and Feldene gel, however, contain menthol and piroxicam respectively, known to cause an increase in skin temperature

when applied topically.[11] Thus, the difference in the pre- and post-insonation skin temperatures, which was used as a measure of transmissivity in this study, could have been brought about in part by this known effect of these two analgesic agents. The heating effect brought about by the friction between the transducer and the skin cannot be overlooked. Shea butter (*ori*) is a non-aqueous semi-solid which has been reported by Griffin[8] to increase in temperature during ultrasound application. This may partly explain the high relative transmissivity of shea butter when compared to the Aquasonic gel.

LIMITATIONS

Two apparent limitations to this study were the small sample size and the index of transmissivity (skin temperature change) employed. The contribution of the heat produced by the frictional effect of the transducer head was not considered as a confounding variable in this study.

CLINICAL IMPLICATION

Shea butter and honey, two of the substitute couplants studied, are readily available locally and are comparatively cheap. In addition, unlike the manufacturer's Aquasonic gel that solely transmits ultrasonic energy, these local couplants also have proven therapeutic properties. Specifically, honey has been used to accelerate the healing of ulcers.[12] Herein lies their merit over Aquasonic gel. In this study, however, shea butter exhibited greater variability in changes in skin temperature following insonation than Aquasonic gel and honey. Honey, therefore, appears to be the most acceptable substitute for Aquasonic gel. The drawback in the use of honey is, however, its sticky nature which may constitute a nuisance. Feldene and Bengay have been routinely used as phonophoretic agents. This study confirms that these two couplants indeed transmit ultrasonic energy and this justifies their continued use. The varying transmissivities of the couplants has also indicated that there is a need to adjust the dosage of ultrasound energy appropriately during ultrasound application.

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