MICROWAVES ARE NOT HYPERTHERMIA

ABSTRACT

Ionising radiation therapy for cancer is unique because it reduces a cancer colony by exponential proportions when delivered at a constant daily dose. Because no other method has such characteristics, any radiosensitizer which increases the rate of this exponential kill must improve cancer therapy results. Hyperbaric oxygen and simple heating to 41.8 C each effectively increase sensitivity between 2.5 and 3 times. 433-434 MHz microwaves (UHF or ultra high frequency radiation) delivered before x-ray therapy are much more effective radiosensitizers, act on all cancer and are apparently free from sequelae and complications. Since 434 MHz microwaves create an increase of radiosensitivity ranging up to one hundred times without raising the cancer temperature above 41.8 C then the radiosensitization is not due to the temperature induced. The radiosensitization is part of the phenomenon of the fluorescence of cancer to UHF. Human cancer in the living host absorbs 434 MHz electromagnetic radiation and re-radiates at a lower photon energy (frequency) and a higher intensity.

Introduction

Both heat and radiowaves have long been known as radiosensitizing agents. Radiowaves were in use between the two World Wars for this purpose.[1] The effects of simple heating on sensitivity have also been well summarized in a review article.[2] In personal experience from treating patients in a hyperbaric chamber (since 1968) and using whole body wax bath (simple hyperthermia) to 41.8 C in 1972-73, it is obvious that both methods produce some increase of radiosensitivity.[3] However, a factor of 2.5 or 3 is insufficient to alter the cure rate of cancer patients unless the tumour is still in an early small stage. Hyperbaric therapy suffers from the great disadvantage that in human practice it is a radiosensitizer of value only for head and neck cancer, uterine cancer and some cutaneous squamous cell cancer (some vaginal and skin lesions). Whole body heating is a method which will increase the radiosensitivity of all cancers at any site in the body and, as shown by its proponents, is relatively safe.[4] The evaluation of radiosensitivity of skin cancers at elevated temperature was performed on superficial malignancies on the hand and forearm of patients (Fig. 1 a & b). The temperature was elevated with a hot water bath and the temperatures were measured using a platinum thermocouple. The increase of radiosensitivity was between 2.5 and 3 on each occasion. A full treatise on the method of calculating the radiosensitivy is included in the appendix.

To treat the majority of cancers, whole body heating has to be by wax bath which is complicated, time consuming, labour intensive and costly. In an endeavour to avoid whole body wax bath heating, electromagnetic wave (diathermy) heating was investigated. Since the mid twenties diathermy apparatus has been available for physiotherapeutic purposes which operate at various frequencies, chiefly 13, 27, 434, 915 and 2450 MHz. 2450 MHz suffers from the disadvantage of selective absorption in the subcutaneous fat tissue and the lens, causing cataracts. Absorption in the fat layer prevents further penetration without overheating it. 915 MHz (the United States standard frequency for diathermy) has poorer depth dose distribution than the phantom absorption characteristics for 434 MHz published by Siemens and Erbe Electromedizin.[5] 27 and 13 MHz (in common use for diathermy purposes in the U.K.) were also investigated. Subjective patient symptoms mediated against using these frequencies. For a given dose of energy absorption surface heating is a problem as also is the method of projecting the energy into a human body. By contrast the 434 MHz systems developed by Siemens, Philips and Erbe Electromedizin throughout Europe (this is the preferred frequency for electromedical uses in Europe) showed that at least 10,000 patients a day were so irradiated without any reports of adverse effects. Purchase of a 434 MHz 200W diathermy machine was contemplated when a device assembling 12 units to radiate the whole body appeared on the German market. This was released under the trade name of Tronado which referred in German to it creating a tornado of electricity in the body. In 1974 a unit of this equipment was purchased. It was used immediately as a radiosensitizing device because of the unequivocal mathematical conclusion that combined UHF and x-ray therapy will kill more cancer per rad than x-rays alone (see appendix for this proof) coupled with the safety record of UHF on thousands of non-cancer patients.

J. A. G. Holt
Radiation Oncology Centre
24 Salvado Road
Wembly, Western Australia, 6014.

Principles Underlying Treatment Policies

It was reasoned that a radiosensitizing device must create some change in the cancer so that the x-ray dose became more effective. The 434 MHz (microwave) therapy was therefore delivered immediately before x-ray treatment. The first patients treated revealed such rapid, obvious and unusual tumour regressions that this method has been used ever since. Similar extent and speed of remission cannot be obtained if the x-rays are given first. It soon became obvious that patients were not appreciably heated by the microwaves during their treatment and this stimulated a program of temperature monitoring before and during treatment. With the help of Dr L. Bowen (then in the Department of Physics, Institute of Technology of New South Wales) external telethermography (using an infra-red Aga telethermography unit with 37 C blackball reference) for surface temperature measurements and the implantation of platinum thermocouples for deeper measurements was carried out.

Head and neck cancer was chosen as the primary trial vehicle for the Phase I. studies. Fourteen months after every consecutive patient attending this practice had been treated with combined microwaves and x-ray therapy (total of 52 patients) an analysis of the results was made. These patients were compared with the latest 52 patients who had been treated on conventional 4 MEV therapy

Fig. 1(a): *see appendix 3*

Fig. 1(b)

(at Sir Charles Gairdner Hospital under the same radiotherapists) and with the latest 52 patients who had been treated using combined hyperbaric and telecobalt therapy at Royal Perth Hospital (the same radiotherapy team also treated these). The results were published[6] and convinced us of the need to persevere with this method. A follow up series published in 1986[7] reveals that the improvement in treatment results can be maintained. The interest shown in this series was responsible for a visit in 1976 by the late Professor William Caldwell M.D. of the University Department of Human Oncology, University of Madison, Wisconsin, USA. He reviewed the patients who had been treated in the first series. His report and analysis of his findings were published shortly after.[8]

The Fundamental Differences Between Cancer and Normal

Cancer has different electrical characteristics to that of normal tissue. Normal tissue is a reasonably good insulator. Cancer tissue is a much better conductor of electricity and its characteristics approach that of a poorly conducting metal.[9] When a normal animal or human is placed within the near field of an antenna emitting electromagnetic radiation, energy is absorbed and reveals itself by an increase in temperature, sweating, increase of pulse rate, blood pressure and all the other physiological signs of heating. The same frequency radiation is reflected back from a normal subject as that which is shone upon it.

Where there are large masses of cancer present, the absorption of electromagnetic radiation in the cancer is much greater than the normal tissue. There is thus selective heating. Selective hyperthermia of cancer can be achieved easily with any frequency of electromagnetic radiation from a direct current up to the higher GHz range. When the incident electromagnetic energy is at a frequency between 425 and 440 MHz cancer absorbs the radiation and re-radiates at a lower frequency but a higher intensity. These features are those of fluorescence. At 434 MHz incident radiation cancer fluoresces readily. Every malignancy which was investigated exhibited fluorescence. With the relatively insensitive wave analyser that was used in 1974 this effect could only be observed where the cancer target was about 2cms diameter or greater. If, after this fluorescence has been demonstrated on a cancer patient, the blood glucose level is reduced by intravenous insulin then there may be alterations in this fluorescence. If a patient is rendered unconscious, from low glucose concentration in the brain, it may be observed that the fluorescence of cancer disappears.[10] The fluorescence can be restored immediately by giving an injection of intravenous D-glucose. Perhaps sufficiently sensitive apparatus would reveal fluorescence also from those normal tissues which are dividing to keep the normal body healthy. Adequately sensitive equipment to test this theory has not been available.

Such fluorescence could not be demonstrated at 13, 27 or 915 MHz. A series of approximately 40 patients treated with 27 MHz and a further smaller series treated

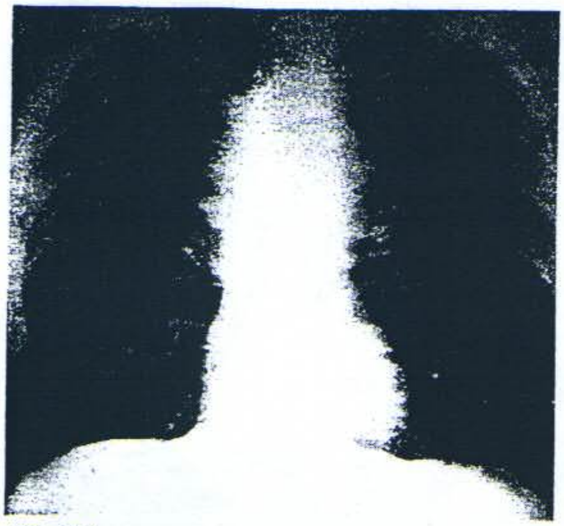

Fig. 2(a)

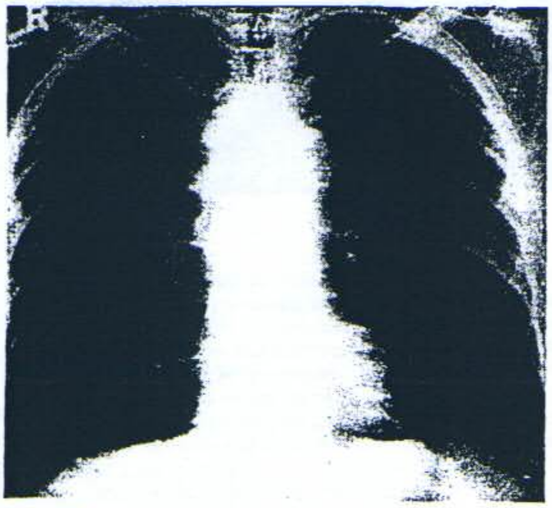

Fig. 2(b)

with 13 MHz prior to x-ray therapy obtained only moderate improvement in radiosensitivities and none have survived long term. Trials of 13, 27 and 915 MHz have been abandoned, concentrating on 434 MHz . An analysis of the approximate radiosensitivity increase created by these frequencies shows that they do not exceed the increase created by simple hyperthermia to 41.8 C. None of these frequencies exhibit fluorescence that could be demonstrated on a wave analyser. However, at 434 MHz used prior to x-ray therapy not only is the fluorescence always present in the case of proven cancer but the radiosensitivities all exceed those which we know can be created by maximum tolerable hyperthermic temperatures.

The conclusion therefore is that all cancer has differing electrical conductivities from normal tissue and that this conductivity is dependent somehow on the glucose metabolism of the cell (Fig.2 a & b).[9] All cancer will be warmed selectively by any frequency electromagnetic radiation. This leads to an increase in radiosensitivity which corresponds to the temperature created. In addition 433 to 434 MHz causes cancer to fluoresce. This fluorescence is associated with an increase in radiosensitivity from twice to two or more decades and is not associated with the temperature created. 434 MHz electromagnetic radiation thus is responsible for two effects: A non-specific thermal radiosensitizing effect and a specific non-thermal radiosensitizing effect. It is this latter effect which was discovered in 1974 that has been exploited as a radiosensitizing tool.[11]

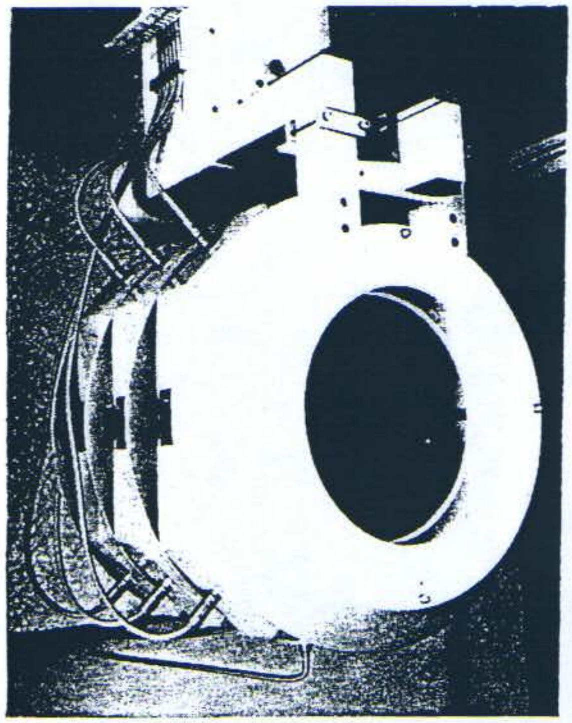

Fig. 3

Proof of Non-thermal Radiosensitization

The radiosensitivity constants[12] of human cancers were estimated according to the calculations detailed in the appendix. The average value for the sensitivity of a series of head and neck cancers was 9 rads. The average value of the radiosensitivity for the 52 patients treated by x-rays under normo-thermic non-UHF conditions was 160 rads and the corresponding value for the 52 patients treated with hyperbaric oxygen was 69 rads.[3,13]

Since UHF may increase the x-ray sensitivity of a squamous cancer by an average of 18 times at a temperature less than that created by non UHF techniques which have a maximum increase of radiosensitivity of only 2.5 times, 434 MHz must have specific non-thermal effect on cancer. The three year cancer-free survival of the 52 patients treated by UHF plus x-ray therapy is nearly twice as good as those treated with hyperbaric therapy which again is nearly twice as good as conventional therapy.

therapy and 52 sequentially treated with hyperbaric oxygen and telecobalt therapy up to June 1975. Table 1 summarises the improvement due to synergistic UHF therapy. These improved results are being maintained: in 1986 the second review[7] confirmed that conventional therapy in Western Australian public hospitals produced approximately one quarter the three year survival rate of the patients of the author.[6,14]

2. *Oesophageal Cancer*

Combined UHF and x-ray therapy produces immediate relief of oesophageal obstruction. One to three doses of UHF and 150 rads usually restores patency for fluids. At doses of 2,250 rads most patients can swallow well masticated solid food. Twenty-seven late stage oesophageal cancers were treated for dysphagia. Twenty-five had complete relief maintained until death (average 11 months, 3 survive more than 2 years) and 2 required dilatation and permanent intubation. Two months after UHF and x-ray treatment the barium swallows of 11 of them showed neither obstruction or mucosal lesion. See Figs. 6 a & b.

3. *Gastro-Intestinal Cancer*

UHF will sensitize most gastric, biliary and colonic cancers to respond using 150-160 rads XRT per day. Several summaries of the universally improved palliative treatment that microwaves add to conventional x-ray therapy are available.[15,16] Typical of the combined treatment responses is that of a 57-year-old patient whose x-rays are reproduced, (Fig. 7). She had an inoperable fixed carcinoma of the common bile duct. It was impossible to cannulate it surgically and a draining T-tube was inserted in the upper part of the common bile duct. Injections of the dye only produced a retrograde flow (Fig. 7a). Following combined UHF and x-ray therapy (160 rads per day, microwaves before XRT alternate days to 4000 rads approximately) the lesion disappeared and the bile duct reappeared (Fig. 7b). This lady unfortunately perished in a road accident several months later and at post mortem there was no residual cancer within the treated area. A similar technique was used on a man who suffered from a primary hepatoma. Figures 8a and 8b confirm clinical disappearance of his liver mass. His biochemistry returned to normal and he remained well when seen 18 months later.

	1978 REPORT		1985 REPORT	
	EMR	SVT	EMR	SVT
Total patient No. in each group	52	52	79	218
Average age (years)	71	69	63	68
Site of primary (%)				
Larynx	13.5	13.5	28	26
Pharynx, pyriform fossa	23	32	14	13
Mouth, tongue, tonsil, palate	48	40	25	36
Nose, nasopharynx, sinuses, ear	13.5	11.5	19	12
Salivary glands	2	4	14	12
Staging				
T_3 and T_4	50	50	31	57
N_2 and N_3	40	45	38	49
Complete primary resolution (%)	94	36	92	34
Crude 3-year survival (%)	54	19	68	17
Crude 8-year survival (%)	40	11	NA	NA

NA = not applicable.

TABLE 1: 401 patients with proven primary head and neck cancer (92% squamous cell carcinoma) treated by combined UHF & XRT radiation (EMR columns) and ionising radiation alone (SVT Columns).

PATIENT DETAILS	TREATMENT	
	UHF & XRT	XRT ONLY
Biopsy only	3	1
Colostomy only	2	5
Abdomino-Perineal Resection	19	18
Median age (years)	57	59
Range (years)	27 - 90	47 - 80
Sex Ratio (Male/Female)	1.18	1.18
Crude survival after first treatment (months)	26.9	16.3
Range of survival (months)	2 - 128	3 -46
Median survival (months)	22	16
P =	0.005	0.005
TOTAL, each group	**24**	**24**

TABLE 2: Survival of 48 patients with recurrent rectal cancer: treated 1975 - 1979.

4. *Rectal Cancer*

An early pilot study was done of recurrent cancer of the rectum (Table 2). This showed that microwaves before x-ray therapy improved survival in patients with recurrent rectal cancer by approximately fifty per cent (50%). In addition, a few of the patients having combined treatment survived three to five years whereas none of the non-microwave group survived. The Cancer Foundation of Western Australia has accepted a Government research grant to conduct a prospective clinical trial for recurrent rectal carcinoma which is currently in progress.

5. *Bladder Cancer*

All 31 patients treated with Stage T1 (confined to mucosa) and Stage T2 (involving bladder wall muscle) have had complete resolution of their primary cancers. Five have died of metastases yet none have a local recurrence to date. Figs. 8a and 8b show one patient who developed lung metastases which responded with gross clearance of her lungs to UHF + 3,300 rads. Twenty-six remain well, clinically clear, from 12 to 2 years after treatment. Stage T3 (extra-vessical spread) lesions respond well with clearance in treated areas for eighty per cent (80%), (Prostatic cancers respond similarly with long term hormone-free control). All Stage T4 bladders can be palliated in pain relief, cessation of bleeding, reduction of urinary symptoms with UHF and 3,000 rads

Equipment Used

The original Tronado machine was built from 12 Erbe UHF 69 200W generators.[11] They were assembled into a barrel-like configuration in which the patients stood (Fig. 3). This proved difficult if the patient felt nauseated or tired or fainted and the equipment was relocated with the moving elements mounted horizontally (Fig. 4). This equipment is claustrophobic and with the limited output of 200W per antenna requires approximately 6 to 15 minutes to generate the radiosensitivity increases in the malignancy. The equipment was therefore redesigned and a new ring of 4 antennae was built to treat the patients. Since each antenna now carries between 1 and 2 kilowatts of power, and the cables are correspondingly heavier and rigid, the couch was mounted so that the patient could be made to traverse the treatment head rather than vice versa (Fig. 5).

The four generators driving the antennae were designed and manufactured to our specification in West Germany. The four generators operate between 433.8 and 434.4 MHz. Circulators between each generator and its antenna prevent mutual beating or interference. Each generator is a modified TV transmitter. The four antennae are designed to radiate the patient with predominantly H-wave polarised radiation. This minimises the electrical currents generated in the skin and avoids completely any need for superficial cooling. Only two patients amongst over 7,000 treated have had minor patches of skin overheating. This occurs only where subcutaneous cancer masses directly involve the skin.

Treatment is carried out by placing the patient on a movable stretcher. They are then traversed through the four antennae which are energized at a suitable level (100 to 2,000 Watts per antenna). It is impossible to predict how electromagnetic radiation is reflected and refracted at each body layer hence the preference for moving field technology to overcome this problem. For example, in treating a primary glioma one would traverse the centre of the glioma for 30cms above and below the antennal centre. Since it was established in 1975 that this is a non-thermal fluorescent effect there have been no further attempts to measure the temperatures induced. Since the maximum temperature tolerable by the body only induces a radiosensitivity increase of approximately 2.5 times, whereas the fluorescent effect may increase the sensitivity by one or two decades, temperature measurement is irrelevant. With this equipment, radiosensitization will be created in the majority of malignancies with exposures between two and six minutes. In some patients in whom the effect is not as much as desired, then two exposures to the UHF 10-20 minutes apart usually ensures adequate sensitization. The succeeding x-ray therapy must be initiated and preferably completed within 20-30 minutes.

Fig. 4

Fig. 5

Results

1. Head and Neck Cancer

Chosen for the first pilot study, 52 consecutive patients with proven cancer presenting between March 1974 — June 1975 were treated by combined UHF and x-ray therapy. They were compared with the previous 52 sequential patients treated with conventional 4 MEV x-ray

Fig. 6(a) Fig. 6(b)

Fig. 7(a)

Fig. 7(b)

forty-five per cent (45%) achieve apparent complete regression of the pelvis and metastatic disease for extended periods.

6. Hodgkin's Disease

When all conventional methods fail UHF and low dose x-ray therapy will invariably produce further responses. Of the series reported in 1980 of 11 patients resistant to all other methods, 7 are still alive and well, clinically free of disease.[17]

7. Lymphoma, Non-Hodgkin's Lymphoma

a. Retroperitoneal Lymphoma: All 7 treated are alive and well without disease at 13, 13, 13, 12, 12, 11 and 8 years. None have any radiation sequelae.
b. Generalized Non-Hodgkin's Lymphoma: From 12 patients (5 treated with x-ray therapy alone prior to 1974) treated only with UHF and x-ray therapy 8 survive without disease, 4 at 13, 1 at 12, 2 at 11 and 1 at 6 years. One lost sight of at 10 years. Three died, 14, 11 and 10 years after UHF therapy — 1 not of lymphoma.
c. Generalized Non-Hodgkin's Lymphoma: From 18 patients treated with cytotoxics and x-ray therapy, 7 originally treated with cytotoxics prior to 1974, 2 only survive at 6 and 3 years, both with disease.

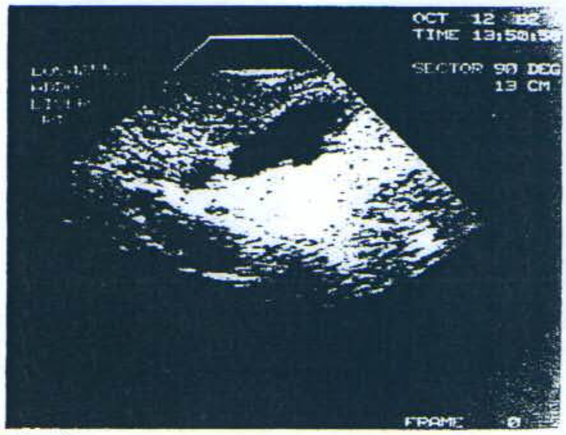

Fig. 8(a)

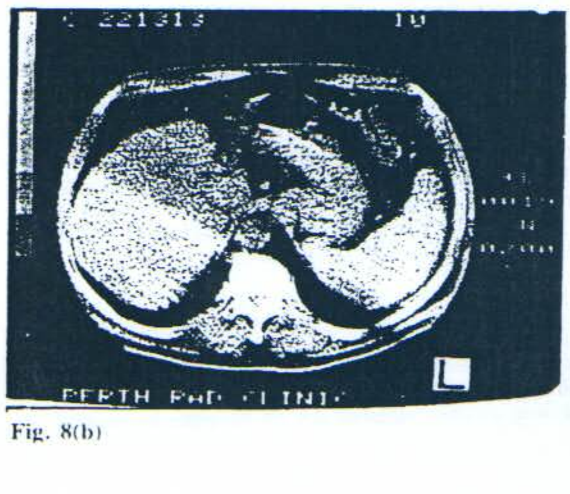

Fig. 8(b)

Fig. 9(a)

Fig. 9(b)

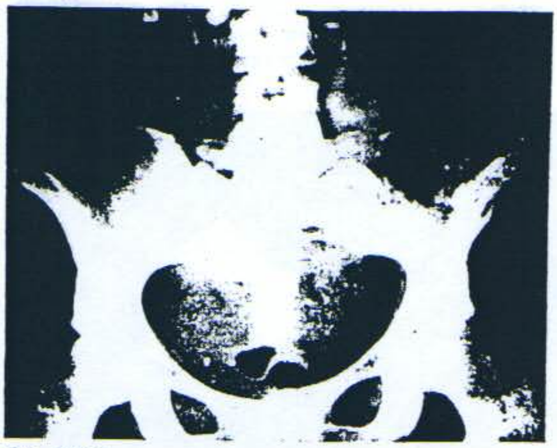

Fig. 10(a)

Fig. 10(b)

Sixteen died, 1 at 8, 1 at 7, 2 at 4, 2 at 3, 4 at 2, 2 at 1 year and 4 at under 1 year.

No patient in groups a or b had prophylactic central nervous system radiation — none developed central nervous system lesions. In group c 5 patients developed central nervous system lesions requiring therapy; 7 had prophylactic central nervous system therapy.[18]

It must be concluded from this experience that central nervous system involvement with lymphoma is likely to be an iatrogenic side effect of cytotoxic chemicals. It is certainly not due to UHF radiation.

8. Other Cancers

All cancers can be sensitized by UHF. Mesotheliomas can be easily palliated with low dose combined radiation: two 5 year survivals exist amongst a small group treated over the years. Glioma, sarcoma, testicular, renal, breast and lung cancers etcetera can all be made to respond readily at low to moderate doses. Large fields to cover extensive disease becomes an effective palliative method because UHF creates responses at much lower doses than with conventional radiation therapy.[19] Figures 10 a and b illustrate the palliation from whole pelvic radiation. Figure 11 a and b show complete regression of a massive breast cancer which remains controlled more than 5 years later. An example of whole body radiation is of Mr C.L. age 34 who was suffering from acute myeloid leukaemia (AML). This patient had come to the end of control using conventional cytotoxic therapy and had an acute blast cell crisis. He was treated with daily UHF to the whole body for 10 days and then 3 consecutive days of UHF plus 150 rads whole body x-ray therapy. Total dose of 450 rads achieved complete clearance of the myeloid cells from his body. This patient was later accepted for Commonwealth Public Service employment. Three years later he was in the Northern Territory and was the first

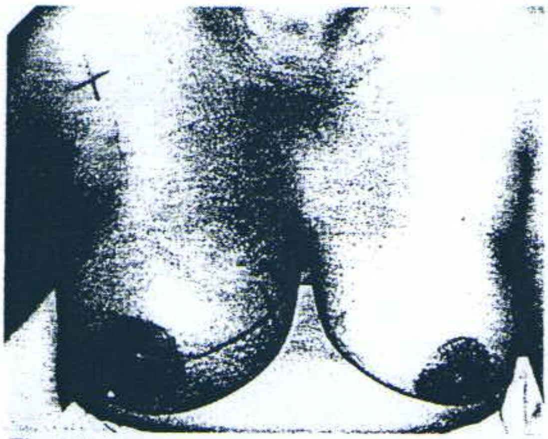
Fig. 11(a)

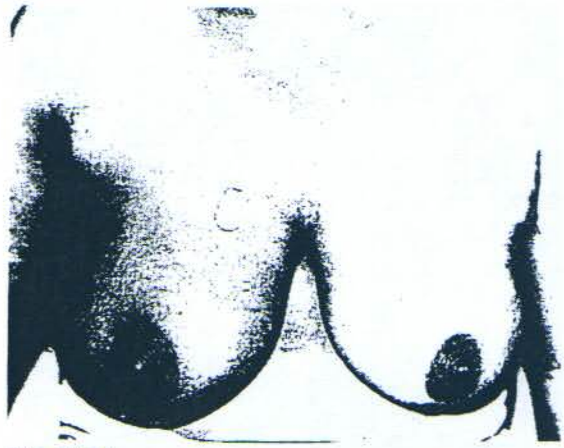
Fig. 11(b)


Fig. 12(a)


Fig. 12(b)

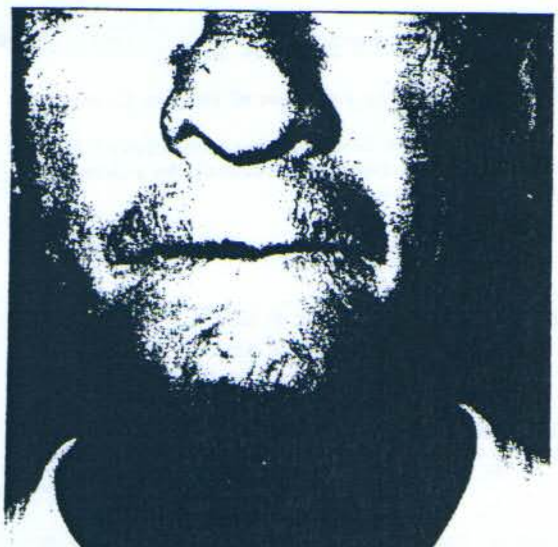
Fig. 12(c)


Fig. 12(d)

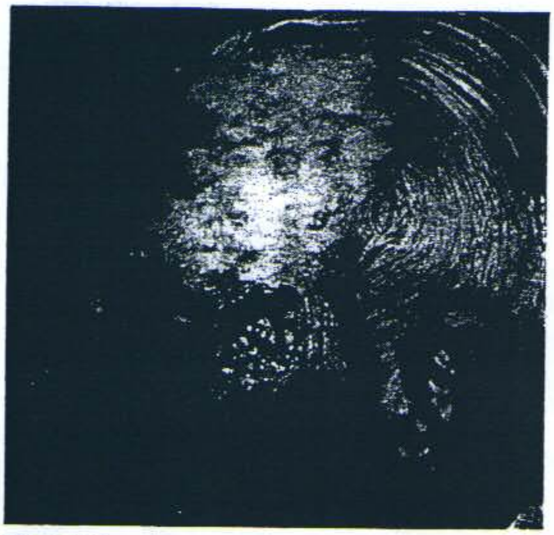

Fig. 13(a)

Fig. 13(b)

victim of AIDS in that State. He contracted AIDS as a drug addict. Autopsy revealed no evidence of residual leukaemic disease. Two further patients with AML have been similarly treated with identical results.

9. Skin Cancers

UHF is particularly effective for all BCC, SCC and other malignant lesions: all sizes, types and situations can be treated using a 200 Watt single radiator from an Erbe UHF 69 generator for 5 minutes prior to 150-180 rads superficial x-ray therapy. Such an example is seen in Figs. 12 a, b, c and d. From the last 600 skin cancers treated only 2 failures have been recorded. A 15cm diameter lesion over the right scapula has partly resolved after 2 courses of 3,000 rads four and a half months apart. A 7cm in diameter BCC on the sternum in a patient with chronic lymphatic lymphoma has only partly responded to similar therapy. UHF stimulates normal healing (see literature on healing of fractures[20] etcetera) and usually results in almost perfect long term cosmetic result (Fig. 13 a & b).

Discussion

Heat potentiates the lethal effects of x-ray treatment on cancer. At the safe limit of tolerance (the liver; 41.8 C) the radiosensitivity increases approximately three times. Any frequency electromagnetic radiation will selectively induce heat in cancer causing similar increase in radiosensitivity. Ultra high frequency radiowaves (434 MHz or thereabouts) additionally causes cancer to fluoresce. This fluorescence is associated with a non-thermal increase of radiosensitivity which may increase by a hundred fold. This non-thermal sensitization rapidly decays. Clinical evidence suggests that the only effective combination utilizing the fluorescent sensitization effect is to treat patients with UHF followed immediately by x-ray therapy. Full doses of conventional radiation can be delivered without increase of side effects if desired, the optimum clinical results in our hands are achieved by alternate days treatment using UHF and 150-160 rads of x-ray therapy on each occasion and taken to or near to the limit of personal tolerance.

Conclusions

Combined UHF and x-ray treatments are simple, economical, practical and safe. Palliation is universally enhanced and in early cancer the cure rates are much improved. No sequelae or complications have been seen from the UHF. The absence of any ionising radiation sequel or complication in over 7,000 treated patients suggests that UHF may exert some beneficial effect on normal repair processes. In the Author's opinion UHF is the greatest advance in cancer therapy since the discovery of radioactivity by Madam Curie.

APPENDIX 1.

Growth and X-ray Response of Human Cancers

Human malignant cancers grow exponentially.[21] Solid cancers can be described mathematically by a Gompertz equation of the form

$$\frac{N_t}{N_o} = e^{\frac{A}{a}\left(1 - e^{-at}\right)}$$

Where N_t = number of cells at time t.

N_o = number of cells at time o.

A is the growth rate and a is the deceleration constant for solid cancer

Expressing e^{-at} as a power series it can be seen that if t is small then

$$\frac{N_t}{N_o} = e^{At}$$ which is the growth equation of non-solid cancers.

Assuming that in a biological system containing N entities and a dose dD destroys dN entities then

$$dN = \frac{1}{D_o} NdD \text{ where } D_o \text{ is a constant}$$

Integrating, thus equation becomes $N = N_o e^{-D/D_o}$

Putting $D = D_o$ we have $N = N_o e^{-1}$

and thus D_o is the dose required to reduce the population to $\frac{1}{e}$ of the original value. This dose D_o is the radiosensitivity value of the of the cancer.[12]

If it is assumed that a multiple hit is required, that is x targets must be hit to destroy a cancer cell, then the survival curve takes the form

$$N = N_o \quad (1-(1-e^{D/D_o})^x)^y \ldots\ldots\ldots\ldots\ldots(E)$$

Assuming that the dose D is given daily for y fractions over a time t regrowth of the tumour takes place so that the number of cells N_s remaining is given approximately by

$$N_s = N_o \quad (1-(1-e^{-D/D_o})^x)^y e^{At}$$

For a given type of cancer cell it may be assumed that x, D_o and A are fixed.

Westra[22] has shown that D_o is altered by heating the cancer cell prior to x-ray therapy and this is confirmed by the results obtained for D_o at 41.8°C during whole or part body wax bath simple hyperthermia. Simple heating to 41.8°C does not apparently alter the value of x, which is the number of distinct targets per cell requiring destruction to kill that cell. UHF reduces D_o similarly (hyperthermic effect) and also may effectively reduce x to 1 (non-thermal, fluorescent effect) by making all targets simultaneously radiosensitive. However, the substitution of reduced values for x in the above radiobiological equations does not alter the results sufficiently to change the conclusions drawn above. The radiosensitivity values of D_o have been calculated using equation E.

APPENDIX 2.

Non Thermal Effects on Cancer Cells

A non thermal effect can be inferred if UHF imparts to cancer a property which the cancer does not have when a similar temperature is created by non electromagnetic wave methods. The radiobiology of x-ray therapy is well understood and such therapy can be precisely administered so that mathematical values of the radiosensitivity of cancer are obtained. Proof of a non thermal effect is possible by comparing the calculated radiosensitivity values of cancer when such cancer is altered by simple heating or by UHF heating to a similar temperature.

Seventeen (17) patients with squamous cell cancers of hands and/or arms were treated whilst hot, with superficial x-ray therapy, using the regime of 150 skin rads (5ma. 140Kv. 5Al H.V.L.) on alternate days (Fig. 1a & b). Heating was either by hot wax bath or electric blanket. Temperatures were measured by an implanted thermocouple at the cancer's base. A total radiation dose of 2,250 (15 × 150) was used.

These patients were followed for a minimum of 2 years. N_o was calculated as approximately 10^9 cells per cu.cm of cancer. N_s was assumed to be fewer than 1000 cells if no recurrence was visible otherwise the assessment was as for N_o. X was assumed to be 2.[23] D is 150 and y is 15, substituted in equation E. The radiosensitivity values for these cancers at 41.8°C treated with x-ray therapy lie between 190 and 60 rads. The average value for these squamous cancers was 66 rads.

52 consecutive patients suffering from head and neck squamous cancers treated by UHF prior to x-ray therapy were compared with 52 consecutive patients with similar cancers treated by x-ray therapy in air at normal temperature (6). 37 of the 52 patients treated by UHF and x-ray therapy had temperature measurements performed immediately after receiving UHF and prior to their x-ray therapy. The average temperature reached was 40.4°C (maximum recorded was 41.1°C). The maximum differential temperature in this series was 3.8°C, the minimum 1.0°C, the average was 2.8°C. The average radiosensitivity of this series is 9 rads. The average radiosensitivity for the 52 patients treated by x-rays under normo-thermic conditions was 160 rads.

Since UHF increases x-ray sensitivity of a squamous cancer by 18 times at a temperature less than that created by non UHF techniques which increase radiosensitivity by only 2½ times, 434 MHz must have specific non thermal effects on cancer.

Conclusion

UHF has non specific thermal and specific non thermal effects on cancer.

APPENDIX 3.

Fig. 1A & B:

Proven squamous cell carcinoma on the dorsum of the left hand. (Fig. 1A). This was one of the lesions treated according to the technique described in the appendix and used to calculate radiosensitivity constants. Microwaves were delivered by a single radiator, 200W from an Erbe UHF 69 generator for 5 minutes and then treated with 150 rads superficial therapy 5MA/140Kv no filter. 15 treatments given on alternate days to a total dose of 2,250 rads. The Figure 1B shows the result two years later.

Fig. 2A & B:

A patient aged 32 who presented with multiple metastatic disease from a primary teratoma of the testis which had been treated by local surgery, radiotherapy to para-aortic nodes and three courses of cytotoxic chemotherapy. The metastases were continuing to grow (Fig. 2A). He was treated with three doses on alternate days of hypoglycaemia and microwave therapy to the chest. Hypoglycaemia was created by an intravenous injection of 2,000 units of soluble insulin and treatment was commenced two hours after that injection. Blood glucose levels were monitored carefully. After the end of the third session he became mildly hypoglycaemic and was given three litres 20% glucose intravenously. Figure 2B shows the remarkable clearance of some of the lung secondaries one month later.

Fig. 3:

The original UHF therapy treatment unit in 1974. This is the original Tronado machine comprising 12 Erbe UHF 69 200W generators. The patients stood amongst them. It required 15-20 minutes to obtain the desired radiosensitization effect.

2

Fig. 4:

The apparatus in Figure 3 was placed horizontally to overcome the problems of patients standing erect for 20 minutes therapy. The patients were kept still, the antennae were moved over them.

Fig. 5:

The UHF treatment unit manufactured to our specification by Hüttinger in West Germany in 1977. The patients were traversed through the 4 antennae, each of which can be energized at between 100 and 2000W. Adequate radiosensitization can be provided with between 3 and 5 minutes exposure to this system in most instances. Four modified TV transmitting generators provide the power: a circulator between each generator and its antennae prevents beating between the units.

Fig. 6A & B:

Figure 6A is a barium swallow of a squamous carcinoma immediately behind the arch of the aorta taken on 10th January 1984. It was treated with UHF followed by 150 rads of telecobalt therapy using a rotation technique to treat a cylindrical volume around the malignancy. 30 treatments were given on alternate days to a tumour dose of 4,500 rads. One month later Figure 6B reveals almost complete disappearance of the lesion. The patient was well palliated, swallowing well and had no further dysphagia until his liver secondaries caused his demise 15 months later.

Fig. 7A & B:

An inoperable fixed carcinoma of the common bile duct was cannulated by a draining T-tube above the obstruction (7A). After a combined course of UHF and x-ray therapy at 160 rads per day to a total of approximately 4,000 rads, the lesion disappeared. An injection of dye into the T-tube now shows that the common bile duct is patent through into the duodenum (7B). An autopsy 9 months later, following her death in a road accident, revealed no local residual malignancy.

Fig. 8A & B:

A 52-year-old who had a primary hepato-cellular carcinoma. (Abnormal Ultrasound scan, A). Biopsy confirmed the disease and he was treated with a combined course of therapy and the CT scan (Figure 8B) reveals a normal liver. His Ultrasound was also normal. Liver function tests also returned to normal following treatment.

Fig. 9A & B:

The lateral chest x-ray (Fig. 9A) view of a lady with a Stage IV cancer of the bladder which had been successfully treated by combined therapy. She now presented with shortness of breath due to metastatic disease in the mediastinum affecting the great vessels and heart. Figure 9B shows complete regression of the disease at the dose of 3,000 rads (total) when combined with microwave therapy. No complications from therapy arose and she returned to good health until liver secondaries developed which she declined to have treated.

Fig. 10A & B:

This post-menopausal 62-year-old lady with metastatic breast cancer in the left pelvis and hip (Fig. 10A) was bedridden and treated with combined therapy to a total dose of approximately 3,600 rads. Figure 10B shows the repair that was achieved by this combined course of therapy. This lady had multiple metastases in her spine, calvarium and ribs which were also treated and all healed. When last seen 5 years later she was asymptomatic.

Fig. 11A & B:

Reveal a large four quadrant carcinoma of the right breast before treatment (Fig. 11A). The response in Figure 11B has been typical of the majority of the breast cancers treated. Three years later this patient has an apparently normal right breast. Figure 11B was taken one month following the completion of therapy to show the maximum reaction which occurred after a course of UHF combined with 4,800 rads total tumour dose (30 doses of 160 rads each on alternate days).

Fig. 12A & B:

A 47-year-old man who had had an excision of a squamous cell carcinoma of the lower lip followed by a course of superficial x-ray therapy. When seen he had a recurrence on the lip (Fig. 12A) proven by biopsy and malignant nodes present in the right upper deep cervical region in the right sub-mental and sub-mandibular regions (Fig. 12B). These were causing gross oedema of the face and neck. Figures 12C & D reveal the situation 5 years later after a course of combined therapy to a tumour dose of approximately 4,500 rads in 8 weeks. He remains well and it is now 11 years since treatment.

Fig. 13A & B:

Figure 13A shows a patient with a massive recurrence in an area which has been grafted for multiple basal and squamous cancer. The area of graft extends up to the hair line and is peppered with multiple recurrences of basal carcinoma. A large squamous carcinoma has destroyed the zygomatic part of the graft and ulcerated through it. Three months later after a course of combined treatment, not only are the BCC elements cleared but the squamous cell lesion has also disappeared with an excellent cosmetic result (Fig. 13B). This was well healed when seen 3 years following this treatment.

References

1. Denier, A. The treatment of in-operable cancers: their radiosensitization by 80cm microwaves combined with low dose x-rays. (Fr) Arch. 0; **Electric Med.** 1936. 44:403.
2. Selawry, O. S., Carlson J. C., and G. C. E. Moore. Tumour response to ionising rays at an elevated temperature. A review and discussion. **Am.J. Roentgenol.** 1958 80:833.
3. Holt, J. A. G. Increase in x-ray sensitivity of cancer after exposure to 434 MHz electromagnetic radiation. **J. Bioeng.** 1977 1:479.
4. Pettigrew, R. T. and M. Henderson. Induction of controlled hyperthermia in treatment of cancer. **Lancet** 1971 June 19. 1275.
5. Kebbel, W., Krause, W. and J. Paetzold. Comparison of Energy Distribution in Fat/Muscle Layers of Long Decimetre Waves and High Frequency Waves. **Elektromedizin** 1964 3:9.
6. Nelson, A. J. M. and J. A. G. Holt. Combined Microwave Therapy **Med. J. Aust.** 1979, 2:88.
7. Holt, J. A. G. and A. J. M. Nelson. Combined Microwave Therapy. **Med. J. Aust.** 1985, 142:707.
8. Caldwell, W. L. Evaluation of the Perth experience in treating with ionising radiations & VHF (434 MHz) radiations. **Int. J. Radiat. Oncol. Biol.Phys.** 1979, 6:1919.

9. Joines, W. T. et al. Microwave Power absorption differences between normal and malignant tissue. **Int. Jl. Rad. Onc. Biol & Phys.** 1980 6:145-192.
10. Holt, J. A. G. The extra nuclear control of mitosis and cell function. A theory of cellular organisation. **Medical Hypoth.** 1980, 6. pp 151-152.
11. Holt, J. A. G. The use of UHF Radiowaves in cancer therapy. **Austral. Radiol.** 1975 19, 3:223.
12. Johns, H. E. In the Physics of Radiology, 2nd Edition. Pub. Thomas, Illinois USA. 1964: pp. 660-668.
13. Holt, J. A. G. The cause of cancer: biochemical defects in the cancer cell demonstrated by the effect of E.M.R. glucose & oxygen. **Med. Hypoth.** 1979 5:109.
14. Holt, J. A. G. and R. W. Stanford. The synergism between hyperthermia and ionising radiation. **Br. J. Radiol.** 1986 59:795.
15. Holt, J. and A. Nelson. Four years microwaves in cancer therapy. **J. Belgian Radiol.** 1979, 62:467.
16. Holt, J. A. G. 434 MHz as an adjuvant in Cancer Therapy. In: Progress in Radio Oncology 11 (K. H. Kaercher et al, eds.) Power Press New York. 1982, p425.
17. Holt, J. A. G. Alternative therapy for recurrent Hodgkin's Disease. **Br. J. Radiol.** 1980 53:1061.
18. Nelson, A. J. M. and J. A. G. Holt. Microwave adjuvant to radiotherapy & chemotherapy for advanced lymphoma. **Med. J. Aust.** 1980, 1:311.
19. Hornback, N. B., R. E. Shupe, C. Marshall and R. Baker. Experience in clinical hyperthermia & radiation therapy in patients with advanced cancer. In: Progress in Radio Oncology 11 (K. H. Kaercher et al, eds.) Power Press, New York 1982, p435.
20. Burney F. Ed: Electrical stimulation of bone growth and repair. Springer — Verlag. Berlin. 1977.
21. Laird, A. J. Dynamics of tumour growth. **Brit. J. Cancer** 1964 18:490.
22. Westra, A. "The Influence of Radiation on the Capacity of In Vitro Cultured Mammalian Cells to Proliferate." Ph.D. Thesis, University of Amsterdam (1971).
23. Andrews, J. R. The Radiobiology of human cancer in radiotherapy. WB Saunders Co, Philadelphia, PA, USA 1968.

This paper was delivered originally as an address at the 5th Radiotherapy Symposium, Perth, 1987.