**INTRODUCTION**

Sound is usually defined to be any compressional disturbances travelling through a material in such a way that it is capable of setting the human eardrum into motion, thereby giving rise to the sensation of hearing. Sound waves, compressional in materials, require a medium to travel. Sound waves can not travel through vacuum as there is nothing to transmit the wave compression.

Ultrasound is the name given to the study and application of sound waves having frequencies higher than those to which the human ear responds (about 16 Kc/s) and frequency is too high for perception by the human ear. For definiteness the lower frequency limit for ultrasound is often taken rather arbitrarily as 20 KHz. The sound which is above 20 KHz is known as ultrasound. The sound below 20 KHz is known as infrasound. In between 20 and 20,000 KHz frequencies, sound is perceivable by human ear. Ultrasound waves exhibit the same physical properties as that of the audible sound waves.

The distance covered by one cycle is termed as wave length $\lambda$ of the ultrasound. The number of cycles introduced in to the medium is referred as frequency $V$. The product of the frequency and wave length is the velocity $C$ of the wave i.e $C = VA$. 
The intensity of an ultrasound wave is the rate at which energy is transmitted by the wave, described usually in units of watts per square centimeter. This is related to the maximum particle velocity or the maximum wave pressure.

Ultrasound has become increasingly important in medicine and has now over taken X-ray and nuclear medicine as a diagnostic tool. Its main attraction as an imaging modality lies in its non-invasive character and ability to distinguish interfaces between soft tissues. In contrast, X-rays only respond to atomic weight differences and often require the injection of a more dense contrast medium for visualisation of non-bony tissues. Similarly, nuclear medicine techniques measure the selective uptake of radio-active isotopes in specific organs to produce information concerning organ function. Radio-active isotopes and X-rays are, thus, clearly invasive. Ultrasound is not only non-invasive, externally applied and non-traumatic, but also apparently safe at the acoustical intensities and duty cycles. Ultrasound can be used both for diagnostic as well as therapeutic aspects. While diagnostic ultrasound involves microwatt intensities, the therapeutic ultrasound involves high intensities above the range of $1W/cm^2$.

Diagnostic ultrasound is now being used to obtain images of almost the entire range of internal organs in the abdomen, major being the kidney, liver, spleen, pancreas,
bladder, major blood vessels and the fetus during pregnancy. It has also been usefully employed to present pictures of the thyroid gland, the eyes, the breast and a variety of other superficial structures and soft tissues. In a number of medically meaningful cases, ultrasound diagnostics, have made it possible the detection of cysts, tumours or cancer in these organs. This is possible in structures where other diagnostic methods by themselves were found to be either inapplicable, insufficient or unacceptably hazardous. Ultrasonic studies which do not involve image formation have also been extensively developed to allow the dynamics of blood flow in the cardiovascular system to be investigated with a precision that was not previously possible. Havlic and Taenzer (1979) gave an over view of pricipies and instrumental method of medical ultrasonic imaging devices.

A sound wave, compressional in nature, is composed of regions in which the medium is alternately compressed and stretched or rarefield. Compressional waves can give rise to transverse waves in which the particle in motion is perpendicular to the direction of wave propagation, where as in longitudinal wave, the particle motion is along a line parallel to the direction of ultrasound propagation. Longitudinal mode of wave propagation is normally used in medical ultrasonic diagnostic application, as these waves can be propagated in all types of media viz., solids, liquids
and gases. Near (the source) fields are usually very complex, but the "far field" is simpler, having characteristics similar to the traveling waves.

A stationary plane wave is set up when a traveling plane wave in a lossless medium i.e. a medium in which the attenuation coefficient is zero, impinges on a boundary at normal incidence and is totally reflected. To reconstruct the stationary wave, the reflected and incident waves are superimposed.

Though ultrasonic waves exhibit the same physical properties as those of audible waves, they are particularly preferred in situations favoured by one or more of the following reasons.

Ultrasonic waves can be easily focused, i.e. they are directional and beams can be obtained with very little spreading.

They are inaudible and are suitable for applications where it is not advantageous to employ audible frequencies.

By using high frequency ultrasonic waves which are associated with shorter wavelengths, it is possible to investigate the properties of very small structures. It is particularly true in detection of defects where the
wavelengths utilised should be of the same order as the dimensions of the defect.

Information obtained by ultrasound, particularly in dynamic studies, cannot be acquired by any other more convenient technique.

The physical mechanism normally used to generate and detect ultrasonic waves is the piezoelectric effect exhibited by certain crystalline materials which have the property to develop electrical potentials on definite crystal surfaces when subjected to mechanical strain (Mason, 1950) and the entire device is known as transducer. The conversion is also true, which means that mechanical displacement is produced when electrical charges are put on their surface. The effect is demonstrated by crystals of materials like Quartz, tourmaline and Rochelle salt. This phenomenon gives an excellent method for converting electrical energy into mechanical energy and vice versa.

For continuous wave operation the input voltage varies sinusoidally in time with the desired frequency $f$; this frequency usually corresponds to resonance for thickness vibrations of the piezoelectric unit. In order to apply a range of frequencies, use is made of a series of transducers, each for different frequency.
Equipment for medical diagnostic applications of ultrasound includes source transducer (which generate ultrasound) and receiver transducer (which detect ultrasound), although commonly the same units serve both as source and receiver. Therapy equipment usually includes only source transducers. For continuous wave operation the input voltage varies sinusoidally in time with the desired frequency \( f \); this frequency usually corresponds to resonance for thickness vibrations of the piezoelectric unit. For pulsed systems used in therapy and diagnosis the input voltage varies sinusoidally with frequency \( f \) as for continuous operation, but is modulated so that it is switched "on" and "off" according to a desired pattern to generate a series of short pulses, the pulse duration being of the order of several sonic periods, usually 1 ms or less under those conditions, the acoustic parameters such as pressure, do not vary sinusoidally with time. The field is then not characterized by a single frequency, but instead by a band of frequencies.

Ultrasonic energy is transmitted through a medium as a wave motion and, therefore, no net movement of the medium is expected to occur. The velocity of propagation of the wave motion is determined by the density of the medium it is travelling through and the stiffness of the medium. At a given temperature and pressure, the density and stiffness of
the biological substances are relatively constant. The velocity of ultrasound in all body tissue is almost constant. Therefore, the sound velocity in them is also constant. Therefore, the depth of penetration can be read directly from the position of the echo pulse on the calibrated time axis of the oscilloscope trace.

Ultrasound is used not only for display of static patient anatomy but also for identification of moving structures in the body. Approaches to the identification of moving mode (M mode) display of reflected ultrasound pulses and the Doppler-shift method. When there is relative motion between a source and a detector of ultrasound, the frequency of the detected ultrasound differs from that emitted by the source. This is known as Doppler's effect. The Doppler method has a number of applications in clinical medicine, including detection of fetal heart beat and multiple pregnancy, placentation localization, detection of air embolism; blood pressure monitoring, detection of blood flow and localization of blood vessel occlusions (Reid and Baker, 1971, Mc Dicken, 1976).

In most diagnostic applications of ultrasound, use is made of ultrasound waves reflected from interfaces between different tissues in the patient. The fraction of the impinging energy reflected from an interface depends on the difference in acoustic impedance of the medium on opposite
side of the interface. The acoustic impedance of a medium is the product of the density of the medium and the velocity of ultrasound in the medium.

Reduction of amplitude of ultrasonic beam while passing through a medium can be due to its absorption by the medium and its deviation from the parallel beam by reflection, refraction, scattering and diffraction etc., due to inhomogeneities of the specimen. Conversion of acoustic energy into heat is known as absorption. The relative intensity and the attenuation of an ultrasound beam is expressed in decibels (dB) and the absorption co-efficient $L$ is normally quoted in dB/cm. Absorption co-efficients of most soft tissues is in the range from 0.5 to 2 dB/cm/HC. Comparing the various soft tissues among each other one notices that fat exhibits the lowest value of both sound velocity and absorption and the muscle shows the highest values in both respects. In soft tissues, $L$ depends strongly on the frequency and therefore, for a given amount of energy loss, the lower frequency ultrasonic signal would travel more than the higher frequency signal. The tissue absorption is largely due to macromolecular process. Further more, it is shown that factors such as pH and denaturation strongly affect the specific ultrasonic absorption of protein. Thus sonic absorption shows to respond strongly to variation of protein structure.
In general, ultrasonic waves are projected in a medium as a beam. Huygen’s construction may be used to determine the spatial distribution of energy in this beam, which can be conveniently split into near and far fields. In the near field, within the first Fresnel Zone, the beam is cylindrical with little spread. A series of maxima and minima are encountered in this region, as one travels out from the transducer which correspond to constructive and destructive interference. In the far field, the intensity of the beam reduces constantly with distance as it spreads out due to the finite size of the source. The beam shape can be conveniently modified by making use of focusing elements in front of the transducer.

An important aspect of acoustic property is cavitation. It is a kind of sonically generated activity of highly compressible bubbles composed of gas and/or vapour. This cavitation activity variously affects the tissue, like ‘degassing’, ‘pulsation’, ‘microstreaming’ etc. The cavitation can affect bio-systems by virtue of temperature elevation (Hyperthermia) and/or by exerting mechanical stress. However in addition, cavitation can also act by generating free radicals and, thus promoting chemical changes.

It has become traditional to group the cellular effects of ultrasound into thermal and non-thermal
categories. For an effect to be purely thermal in origin, it would have to be such that it could also be achieved by non-acoustic heating, provided that the temperature, history of the target cells during heating and cooling, duplicated during ultrasonic irradiation.

Following this, two sets of thoughts evolved, one concentrating on bio-physical techniques of application of ultrasound on to the biological materials and the second group investigating in detail the effect of ultrasound on the biological material. With further finer improvement of pulse-echo techniques the medical field started employing ultrasound as a diagnostic tool. On the other hand the continuous wave of ultrasound, at different intensities was used for therapy of some diseases and ailments wherein deep seated heating is required, and in tumours degrees of degenerative necrotic changes were achieved. Being a non-ionizing radiation energy, ultrasound is gaining more and more attention in clinical procedures. Present day investigations of ultrasound and its effects on biological media have necessitated the use of different ranges of frequencies and intensities which are now available commercially. This is the result of ardour and zealous work of many workers involved in physical aspects of ultrasound. Although a fixed frequency of 1 MHz is in extensive use, the range of application in the medical field varies from 0.5 to 10 MHz. A combination of continuous
and pulsed emittance is designed with the range of 0 to 21 watts/cm². Inspite of its excellent safety record, ultrasound is likely to produce some unwanted effects, which may go unnoticed at the time of application or immediately following the application. The threshold level must be adhered to, failing which some pathogenic effects might be produced at the tissue level. The histomorphological changes that occur may or may not be in a position to bring about change in the organ and organismal physiology. However a continuous use of this energy, which in the present days is indiscriminately and very frequently being used, could cause damage to the physiology of the organ. This property, is to be thoroughly studied to help the clinicians for proper and selective application of ultrasound on the patients. Large number of advantages like preferential heating depending on the nature of the tissues, the penetration capacity which is inversely related to the frequency and a perfect control with which thermal effects that can be brought about at various depths. Whenever ultrasound is used as means of heating, non-thermal effects also occur simultaneously with the increase in the temperature and these effects can interact constructively or otherwise.

Besides its sole application, ultrasound was used in combination with chemotherapy and radiotherapy. Ultrasound in combination therapy has been found very useful
since it enhances the chemotherapy in human neoplasias and accelerates the radiotherapeutic procedures. Its usefulness in treating the solid tumours is promising because of the ability to localize in the desired area.

Pancreas is a large, elongated, compound, lobulated, tubulo acinar gland placed in the concavity of the duodenum and extends behind the peritoneum of the posterior abdominal wall towards the left to reach the hilum of the spleen. It is both an exocrine and an endocrine organ, the two functions being performed by different cell types.

The innervation of the pancreas is by way of the vagi and splanchnic nerves. Most adrenergic nerve terminals end in relation to blood vessels (Lagg, 1968). Cholinergic nerve endings can be seen in relation to acinar cells (Watari, 1968; Lenninger, 1974). Recently, VIP-immunoreactive nerve terminals have been seen close to the acini and blood vessels (Sundler et al., 1978).

The exocrine pancreatic secretions contain various proteins which are mainly in the form of enzymes. These enzymes include trypsin and chymotrypsin, which split proteins; carboxy peptidase, which cleaves peptides; ribonuclease and deoxyribonuclease, which break down RNP and DNP; amylase, which hydrolyzes starch and other carbohydrates; lipase; which splits the lipid molecules; other proteins present in small amount in pancreatic juice.
includes immunoglobulins, kallikrein etc. (Soto et al., 1977; Shah et al., 1982).

Scattered more or less randomly the islets collectively constitute the endocrine pancreas, secreting several critical important hormones directly into the bloodstream, among insulin and glucagon are more important.

Insulin is a pivotal hormone which directly or indirectly controls various metabolic pathways more particularly the carbohydrate metabolism. It reduces plasma glucose levels both by stimulating uptake of the glucose into tissue and by inhibiting the production and release of glucose from the liver. Production and release of glucose by the liver is reduced in a concreted manner involving several points of attack. Insulin stimulates glycogen synthesis and simultaneously inhibits glycogen breakdown by decreasing the activity of glycogen phosphorylase.

Insulin influences each of the four key control points at which forward and reverse reactions are catalyzed by different enzymes in glycolysis. Conversion of glucose to glucose-6-phosphate, fructose-6-phosphate to fructose diphosphate and phosphoenol pyruvate to pyruvate are all favored. In addition, insulin strongly activates pyruvate dehydrogenase, shunting pyruvate on to acetyl-CoA, which can be converted to fatty acids and stored or enter the Krebs cycle and be oxidized.
One of the immediate effects of insulin is to cause hyperpolarization of the plasma membrane, an effect that must reflect changes in ion fluxes. It increases cytosolic calcium ion levels by effecting release of calcium from bound form within the cell and/or favoring entrance from the extracellular fluid. Since calcium ion, via calmodulin, exercises control over a number of the enzyme systems regulated by insulin, this mechanism may have more general significance.

Glucagon, an antagonistic of insulin, increases the level of blood sugar and causes depletion of liver glycogen. It functions by stimulating adenyl cyclase of the liver, thus promoting breakdown of glycogen to glucose and inhibiting the synthesis of glycogen from UDP-glucose.

There is an interesting interrelationship within the islets between the three hormones secreted. Insulin inhibits the release of glucagon; somatostatin inhibits the release of both glucagon and insulin; and glucagon stimulates the release of somatostatin. There is thus a triangular feedback loop in which glucagon affects insulin release through its effect on somatostatin release; but there is a direct feedback relationship between glucagon secretion and somatostatin secretion.

The liver is a large gland occupying the anterior third of the abdominal cavity. There are four main lobes
joined dorsally. The hepatic duct from the liver and the cystic duct from the gall bladder unite to form the common bile duct. This narrow duct extends posteriorly to the duodenum traversing a portion of the pancreas before passing through the intestinal wall to open on a large papilla.

The hepatocytes are metabolically versatile cells whose most important function is the biochemical processing and distribution of food stuff molecules brought to the liver from the intestinal tract. They store glucose as glycogen, prepare nitrogenous wastes for excretion, and synthesize blood plasma proteins and lipids. They are capable of carrying out all the major "mainstream" metabolic activities of cells.

AIM AND SCOPE

Sonoscanning is a common practice in medicine to detect and display various pathological conditions of various organs including pancreas. The extracorporal shockwave lithotripsy of pancreatic stones or concrements in chronic pancreatitis is another important application of therapeutic ultrasound. There have been scattered reports in the literature with regards to the interaction of ultrasound with various soft tissues. But practically no information is found regarding the influence of ultrasound on pancreas along with sympathetic effects on liver.
Since pancreas plays a major and vital role in digestive metabolism and as well in various biochemical pathways, and the organ is frequently exposed to diagnostic and therapeutic ultrasound, the present inquiry is taken up with an objective of understanding in greater detail the ultrasound interaction with the gland.

The earlier reports have shown that ultrasound enhances the synthetic activity, activates the enzymatic reaction and alters membrane permeability. Keeping this in view the present study is undertaken to verify whether such changes could be seen in pancreas and in turn in liver which are comparatively less explored organs in connection with ultrasonic interaction. Enzymatic studies, exocytosis, ionic strength and other important parameters connected with the pancreatic physiology are taken up for detailed investigation.

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